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ORIGINAL ARTICLES.

I.—On some Physical Changes in the Earth's Crust.

(*Part I.*)

By Charles Ricketts, M.D., F.G.S.

THERE always appears an objection to the agencies by which mountains and hills are formed being designated by such terms as "mountain architecture," "mountain building," etc., leading to the inference that to the deposition of the materials which enter into their composition these elevated regions owe their form and structure. There certainly are mountains which have been built, and some such are at the present time in process of building; but these instances refer only to elevated masses of volcanic origin: they have been constructed as the railway engineer builds his embankments, or, with greater preciseness, as the miner forms the bank at the pit's mouth, by tipping over the rubbish brought from below. To hills and mountains forming volcanic cones the term *mountain building* is quite correct; the volcano in eruption pouring over its lava, and belching forth scoriæ and ashes, which fall and accumulate around its vent.

The term building may also be applied to the formation of the miniature mountain-ranges which, in certain localities, fringe our coast; sand-hills and -dunes being due to the accumulations which the wind has carried landward when the sandy shores are exposed and dry. The term is likewise applicable where receding glaciers have brought down, and discharged as moraines, their burden of stones and rubbish, forming not only small mounds but hills and ridges of considerable size.

With respect to elevated masses such as these, whether great or small, the process of their formation may be correctly termed building; otherwise the formation of mountains is due to sculpture, —to erosion, disintegration, denudation,—and may be compared to the work of the quarryman, rather than that of the builder; to the art of the sculptor and not of the architect. Playfair, in his "Illustrations of the Huttonian Theory of the Earth," considered that "mountains as they now stand may not inaptly be compared to the pillars of earth which workmen leave behind them, to afford a measure of the whole quantity of earth which they have removed."[1]

[1] § 113, p. 127.

Excepting by very few it was formerly assumed that the sculpturing of mountains, and the formation of valleys, etc., were due to the action of the sea. Again, that "the excavation of valleys could be ascribed to no other cause than a great flood of water, which overtopped the hills from whose summits these valleys descend." It has been considered "they are due to cracks, rents and gorges of fissure in the rock-masses, in some of which rivers flow; that these fissures have been caused by upheaval, by rupfures, and denudation," and "that mountain valleys lie in lines of curvature, dislocation and fracture." No endeavour was made to demonstrate how any of these various causes could have excavated valleys, and it is very remarkable that there was no attempt to account for the redistribution of the materials which had been removed. It is probable that the difficulty of making the present conformation of the Earth's surface coincide with a preconceived chronology, may have had great influence in the formation of such opinions, even by those who are justly considered fathers in geological science. We are constantly reminded how greatly this feeling is impressed on the popular mind in expressions made by persons unacquainted with geological science; with those who may be considered educated, "I presume it is antediluvian;" with the workman or labourer, "It was there afore th' flood!" Walking through one of the minor gorges in the Carboniferous Limestone of North Derbyshire, and conversing with an intelligent man native to the district; on the remark being made, that some persons think these dales have been formed by the streams that run through them, the immediate and emphatic reply was, "No! that could never be;" and, pointing to the rivulet, "Why there is not water enough to drown a mouse. You may depend upon it all these places were cut out when the world was drowned."

Hutton (1795) and Playfair (1802) demonstrated that the formation of valleys was due to the effects of atmospheric agencies. Playfair says, "Water in every state from transparent vapour to solid ice, from the smallest rill to the greatest river, attacks whatever has emerged above the level of the sea, and labours incessantly to restore it to the deep. The parts loosened and disengaged by the physical agents are carried down by the rains, and, in their descent, rub and grind the superficies of other bodies; and, when rain descends in torrents, carrying with it sand, gravel, and fragments of rock, it may be truly said to turn the forces of the mineral kingdom against itself. Every separation which it makes is necessarily permanent, and the parts once detached can never be united save at the bottom of the ocean."[1] "All river channels have been cut by the waters themselves; they have been slowly dug out by the washing and erosion of the land."[2]

A long time elapsed before this explanation was accepted, not until there occurred in the early volumes of the GEOLOGICAL MAGAZINE a prolonged discussion on the subject, which proved that a great

[1] Playfair's Illustrations, etc., § 95, p. 111.
[2] Illustrations, § 99, p. 115.

change of opinion had taken place; very many of those who had been led to consider that, in the words of Hutton, "the rivers themselves had hollowed out their valleys," being on the staff of the Geological Survey, whose occupation affords special opportunities for determining such questions; not that they ignored the effects of the waves and tide, but did not attribute to them results which the sea could not produce, occurring where the sea had not been. The author of "Rain and Rivers" (the late Colonel George Greenwood), was the most persistent advocate of the views of Hutton and Playfair. This dashing cavalry officer renewed the assault again and again, never failing to attack any weak point exposed by his opponents.

This discussion was decisive in determining that valleys are formed by rain and rivers, and that the materials, which once filled up the excavations made, had been carried down and deposited in the sea near their mouths; but there still remained to be considered the methods by which this is accomplished. If the crust of the earth were rigid, rivers, by bringing down the disintegrated materials, would simply fill up the sea near their mouths, and, judging from the vast amount which must, during prolonged periods, have been removed in the excavation of valleys, there would be formed level plains or deltas extending over an immense number of square miles, through which the streams would flow. At the mouths of large rivers, and where the sediment derived from the excavation of the land is brought down by them, there is evidence in all cases that the weight of these accumulations in the bed of the sea, on deltas, and in bays, presses down the crust of the earth, and thus accommodates the subsequent accretion of materials. This result may be considered universal and capable of demonstration in strata of all ages, from the earliest Geological epoch to the present time.[1] No expression is in more frequent use than that different formations have been laid down during a period of subsidence. "Everywhere throughout the world," says Prof. James Geikie, "we read the same tale of subsidence and accumulation, of upheaval and denudation.[2] It has only very lately been generally recognized that the weight of the accumulation is the cause of subsidence; at all events when, in a consideration of the subject,[3] opportunity was afforded, there was no attempt to controvert this opinion. The subject is a most important one, and, with its converse, that denudation, by lessening the pressure on the earth's crust, causes the land to rise, may justly be considered the *Alpha* and the *Omega* of physical geology, for to it must be attributed the great movements and changes that take place on the earth.

These areas of deposition may subsequently enter into the structure of mountain-masses and form elevated ground, but, so far as *building*

[1] On Subsidence as the Effect of Accumulation, by C. Ricketts; Geol. Mag. Vol. IX. p. 119, 1872.

[2] Mountains: their Origin, Growth, and Decay.

[3] "Nature" for August 2nd, 1883, and subsequent numbers. In the number for August 30th, 1883, page 413, and October 4th, 1883, page 539, reference is directed to those who have taken the subject into consideration so far as known to myself.

is concerned, the result is the formation of alluvial and marine plains, occurring about or below the level of the sea; it is only on the conditions being altogether changed they become raised, chiefly in consequence of the removal of weight, consequent on the great denudation they have undergone, and thus help to form mountains.

The flanks of mountains are frequently composed of rocks whose strata have undergone disturbance and contortion, and are oftentimes affected by cleavage. These foldings have been referred to as essential features in the formation and "building" of mountains; but they extend as frequently to low ground, and pass beneath deltas and estuaries, and form the base upon which the strata constituting the bed of the sea rest. Geological inquiry shows that after having been raised above the sea-level and become weathered and eroded, the valleys and channels formed may again be submerged, and have their weathered surfaces buried beneath sediments to a depth of several thousand feet.

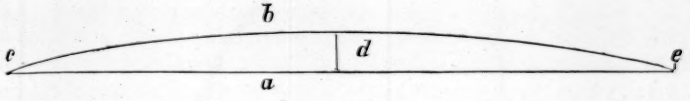
Contortions have been attributed to the forcing of wedge-shaped masses of metamorphic rock upwards so as to penetrate and protrude through sedimentary strata; but in a general elevation affecting a district the whole thickness of the earth's crust must be lifted together, and from a depth which would render such an occurrence impossible. In no instance would it appear more probable that such has taken place than on the flanks of the Malvern Range, had not Miss Annie Phillips[1] (sister to the Oxford Professor) found Silurian organisms embedded in a breccia derived from the disintegration of the metamorphic rock. Her discovery was most important, more so than is generally recognized; proving that during the deposition of the Upper Silurians the Malvern Hills formed an Island, in all probability the summit of a former mountain, buried beneath a great accumulation of strata then in process of deposition, the margins of which consisted of fragments of the metamorphic rock which had fallen down from its sides into the Silurian sea.[2] The contortions in these Silurian strata, or the power that caused them, could not have given origin to the mountain, for its summit was situated above the sea-level during the time of their deposition; on the contrary, its presence may have influenced but not caused, that action by which they are thrown into extensive folds. The rudder does not cause the ship to sail, but determines the direction of its course.

Any movement by which the crust of the earth is compressed into a less lateral space must, to an extent commensurate with the size of the area effected, have a tendency to cause the strata to become bent and contorted. This may result in some degree from the weight of accumulations causing subsidence, and, by thus pressing downwards the earth's crust, cause it also to be compressed within less lateral dimensions, but the lateral pressure thus developed can only be considered as inducing a *tendency* to form flexures; its

[1] Memoirs of the Geological Survey, vol. ii. p. i. p. 66.

[2] Fragments derived from the hills also enter into the composition of the Hollybush Sandstone (Lower Silurian).

extent being limited to the difference between the measurement of the portion of the earth's circumference and the Chord of its Arc included in any area referred to. This variation will be found comparatively so slight as to be utterly inadequate to account for the presence of such foldings as occur in many districts; though it is to such a cause they are not infrequently attributed. The impossibility of these contortions being the result of such subsidence may be best illustrated by taking two slips of wood (Fig. 1 *a*, *b*) of equal length —say 10 feet—fastened together at one end by a hinge (*c*); one (*a*) being fixed so as to remain straight, the other (*b*) bent to represent a curve, the greatest distance (*d*) between the chord (*a*) and the curve (*b*) being six inches; it will be apparent that the distance between the extremities of the slips of wood will be very slightly over three-quarters of an inch (*e*); an amount too insignificant to be



capable by the pressing down of the one upon the other to form foldings such as are frequently met with in geological formations.

(*To be continued.*)

II.—Notes on Altered Igneous Rocks of Tintagel, North Cornwall.

By W. Maynard Hutchings, Esq.

In the autumn of 1887, during a stay in North Cornwall, I paid a hasty visit to Tintagel, and took away a few specimens of rocks, without, however, having time or opportunity to examine more than very superficially into their field-relationships.

In subsequently studying sections with the microscope I found myself unable to correctly interpret some of them, notably a certain highly schistose rock consisting mainly of calcite and chlorite, with residues of triclinic felspars. Mr. Teall, who very kindly looked over several sections for me, suggested that this was a highly altered and mechanically metamorphosed igneous rock, which might prove to be derived from a certain epidiorite occurring not far from it; and made other remarks and suggestions which decided me to pay another and longer visit to Tintagel in the following year.

As a result of this visit, and the subsequent examination of a series of rock-specimens then collected, I venture to offer a few notes on the altered igneous rocks of the coast in the immediate vicinity, viz. from a point near Boscastle to the south end of Trebarwith Strand.

The more or less altered "Greenstones" of the coast further south have been studied and described to a considerable extent. A résumé of the work done is given and discussed in Teall's "British Petrography." So far as I am aware, the corresponding rocks of

the more northern part of the coast have not received a similar amount of attention.

Referring to the map of the Geological Survey of the district, we find no occurrences of "Greenstone" marked along the coast, or its immediate vicinity, from the neighbourhood of Port Isaac to that of Tintagel, where several outcrops are indicated, extending along to near Boscastle, where we pass from the Devonian to the Carboniferous rocks. There are, however, other prominent occurrences of greenstone around Tintagel which are not shown on the map, notably the very extensive exposure at Trebarwith Strand which is alluded to by De la Beche in his "Report of the Geology of Cornwall, Devon, and West Somerset" (1839).

In this report there are several references to the igneous rocks of this special strip of the coast. Thus, on pp. 56 and 57, Beche speaks of "schistose beds" which are intermingled with the "slates and grits which emerge from beneath the Carboniferous system," and describes these schistose rocks as "strongly reminding us of the substance of greenstone, finely comminuted and permitted to settle in water in which calcareous matter was occasionally present." He states that "greenstones, some large-grained, occur near Tintagel, and the trappean schistose rock is also discovered mingled with them, particularly towards Bossiney."

He looks on the "schistose trappean rock" as an altered ash, and considers that the two kinds, compact and schistose, have "probably been erupted, one in the state of igneous fusion, and the other in that of ash, during the time that the mud now forming slates was deposited."

This sharp distinction made by Beche between the compact and schistose rocks of this neighbourhood, and the definite inference he draws as to their different conditions of origin, would not now, with modern methods of examination, hold good in all cases. Passages of his "large-grained" or "compact" greenstone into the most highly schistose rock may be observed which leave no doubt that the original material was one and the same for both.

There are other occurrences of schistose rock whose origin we may safely say was igneous, but concerning which, in their present extremely altered condition, we could not arrive at any safe conclusion as to whether they have been derived from massive or fragmental material.

The occurrence which I will first notice is seen in the cliff at the side of a cove which is not named on the map, and of which I heard no name on the spot. It is the next little inlet south of Bossiney Cove, separated from it only by the neck of land off which lie the rocks called "The Sisters." The exposure in question is at the south side of this nameless cove. There is an outcrop, at the surface above the cliff, of angular craggy blocks, and the continuation may be seen dipping steeply down towards the sea. At the outcrop the rock is coarse-grained and massive, showing no foliation at all. It is very hard and tough, making excellent road-metal, for which purpose it is taken in quantity from a similar outcrop in a field a

little way off. Numerous large irregular grains of hornblende are seen set in a greenish-grey speckled mass. It is doubtless an example of the "large-grained greenstone" alluded to by De la Beche.

A little way down the cliff the rock becomes much foliated, is much altered in general appearance, and is softer; and still further down, near the water, it has become very highly schistose, tolerably soft and easily fissile, differing in appearance in every way from the rock at the outcrop. Foliation is coincident with the dip and with the cleavage of the slates, shales, etc., above and below.

Specimens were taken at three points: No. 1, outcrop; No. 2, a few yards down the cliff; No. 3, near the bottom, a few yards above the level of the sea. Microscopic examination of sections from these specimens shows internal changes corresponding to the outward differences in texture and general appearance.

No. 1 is essentially a hornblende-plagioclase rock. The hornblende is all green, secondary and uralitic. It is mostly pale in colour with very moderate pleochroism, but some portions are of a much deeper colour and powerful pleochroism, the contrast being often seen in contiguous parts of one individual, one portion being nearly colourless, and the other a very deep green, though they extinguish together and give nearly the same colours of polarization.

The felspar is nearly all very turbid, but the columnar form of many of the crystals is still perfect, and they are still fresh enough to show twinning, binary and multiple. The structure of the original rock is shown to have been markedly ophitic by the fact that many of the individuals of hornblende are penetrated by felspar crystals, in some cases being nearly bisected. Crystals of apatite are seen here and there. There is comparatively little chlorite or calcite, but epidote is abundant, both in finely granular form in the hornblende and in crystals and irregular fragments and grains all over the sections. It is all quite colourless and non-dichroic. Leucoxene is plentiful in large plates and patches surrounding varying amounts of residual ilmenite; and some granular sphene may be seen. There are grains and little patches of secondary quartz, and a very few bits of perfectly water-clear, obviously secondary felspar, without any trace of definite form or of twinning, recognized by its optic behaviour.

This rock is a typical epidiorite, of which we may say with tolerable certainty that it was derived from a coarse-grained ophitic dolerite.

Sections of No. 2 show that hornblende is much diminished in quantity, with a corresponding increase in chlorite. All stages may be seen of the passage of the hornblende into chlorite. Calcite is also very much increased in amount.

The felspar is largely in the state of a confused, crushed, turbid mass mixed up with chlorite, without any form or sign of twinning, but with this there are a very large number of bigger grains and patches which are water-clear and contain needles of hornblende in some cases, together with numerous grains of chlorite. But few of these water-clear bits show any twinning. Quartz has increased

also considerably in amount. Leucoxene and epidote remain in about the same proportions as in No. 1.

But it is more the mechanical than the chemical or mineralogical change which is very striking in this part of the rock. It has become very much foliated, and sections cut across the schistosity show in a beautiful manner what a great amount of stress and internal movement it has undergone. The chlorite is drawn out into long, curving parallel bands and streaks, and most of the calcite and leucoxene have been squeezed out into long lenticles, tapering off into thin tails. Hornblende also is crushed into layers, but in a less degree, and much of it is now in the form of detached needles and fibres. Epidote has not been drawn out into streaks, but is more broken up and separated and more or less arranged in lines; and the irregular bits of this mineral lying in among the bands and lenticles of the other constituents which have behaved more plastically, often serve to more distinctly mark the amount of "flow" which has taken place around their angles. It would be difficult, I imagine, to find anywhere a more striking example of the great alteration which may be effected in rock-structure by pressure and shearing-movement than is here given within a space of some thirty yards or less.

Sections of No. 3 show that hornblende has wholly disappeared, chlorite taking its place. Calcite is more abundant than in No. 2, while epidote is nearly wholly absent. It may be stated that over a large number of sections of rocks of this district which I have examined, calcite and epidote very generally appear in inverse proportions. They are, of course, very liable to be *originally* developed in inverse proportions. They both originate from the alteration of the same calcareous silicates, and varying conditions under which this alteration is carried on may give rise to varying amounts of the two minerals in question, even in closely adjoining parts of a rock. But it seems not unlikely that epidote may be altered into calcite under some circumstances. I have seen no mention of this, nor have I detected any epidote actually undergoing the change to calcite. Nevertheless, the frequent oscillation in the relative amounts of the minerals in these rocks has constantly suggested such a change, which is likely enough from a chemical point of view, as a possible explanation.

The most striking change in No. 3, as compared with No. 2, is that turbid felspar has now almost entirely given way to water-clear. Much of it here shows twinning. It is more or less full of bits of chlorite, and other mineral enclosures which cannot be determined. Quartz has undergone a further very decided increase. Leucoxene is still abundant, but some patches of it are seen to be very much altered to rutile in grains; and small crystals of rutile, some as sagenite, are abundant in some parts of the chlorite. The foliation is seen to be more highly developed, the parallelism of the bands of chlorite, etc., being greater, and their course less curved and wavy, which corresponds with the much greater tendency of this part of the rock to split into flattish pieces.

I may here mention that it was a section of this schist which Mr. Teall saw, together with a piece of the epidiorite, though from another outcrop. His suggestion that they might prove to be directly connected in derivation was made at the time without the slightest knowledge of the actual field-relationships, but has proved to be perfectly correct.

We have here, then, a very interesting case of the passage of a massive epidiorite into a perfect chlorite-schist; and doubtless a further series of specimens, taken at shorter intervals, would prove very instructive.

This sheet is of but moderate thickness—a few feet only. It appears to be separated from a very much thicker sheet, which underlies it, by a bed of shale or slate, the contact with which is well seen at the lower part of the cliff. Concerning the question as to whether this and other sheets of igneous material to which I shall allude are intrusive or contemporaneous, it seems that De la Beche regarded them all as being the latter. So far as my own observation goes, I should incline to hold the same opinion, at least as concerns those exposures where a considerable extent of the upper and lower contacts with the slates, etc., is plainly visible. But I would express this opinion with much diffidence, in view of the great disturbances which have everywhere taken place in this district, and the great amount of alteration the rocks have undergone.

The sheet just considered appears to follow the curve of the coast and to wind round towards Barras Nose and the Castle Cove; but much of the intervening shore is inaccessible and examination could not be made. About two-thirds of the way towards Barras Nose there is another outcrop of chloritic epidiorite, intermediate in nature between No. 1 and No. 2.

In the Castle Cove is exposed a sheet of rock which I am inclined to think is very likely a continuation of the one just described, though it is not possible to trace the connection to the point of proof. The nature of the rock is here different in many respects, but nothing is more striking than the considerable and often rapid changes of character which the igneous rocks of this district show. The sheet I allude to is seen on both sides of the Cove. On the left it is inaccessible in the cliffs of "Tintagel Head," but on the right it may be freely examined. It overlies a bed of black shale, with which its contact is sharply defined;—the same bed of shale which, curving steeply upwards from the Cove, passes right under a portion of the "Mainland," part of the Castle. So that originally this sheet of igneous rock swept up over the country inland, but is now wholly removed by denudation. As seen at the right-hand side of the cove, where the fishing-boat is hung on davits, it is a hard, grey, rather fine-grained, moderately-foliated rock. It is a good deal jointed and cracked, and all these cracks are filled with quartz. This is the only case in the district of an igneous rock being veined with quartz instead of the usual calcite.

The microscope shows it to consist mainly of felspar and chlorite, without any trace of original ferro-magnesian mineral or of secondary

hornblende. The felspar is much the predominant constituent, and part of it is better preserved here than in any other local rock I have examined. Much of it is again in the indefinite and untwinned water-clear condition, but with this there are a great many well-twinned crystals of columnar form. Binary twinning is most prevalent. A series of measurements of maximum extinctions shows that much of the felspar belongs to the labradorite-anorthite group, though more acid felspars seem to be present, most likely of secondary metamorphic origin. Chlorite and calcite are in only moderate amount. Secondary quartz is tolerably plentiful, both in grains of good size and as a mosaic of smaller ones. Leucoxene with residual ilmenite, granular sphene, a little epidote, apatite, small flakes of biotite, and rutile in slender needles, and bunches of needles go to make up this rock. Bent and broken crystals of felspar, and strongly undulous extinctions both of felspar and quartz, bear witness to severe strain. The fact that much of the quartz shows these effects of stress goes to prove that the rock was very much altered before this stress was applied.

In the centre of the Cove, almost under the waterfall, another exposure of igneous rock is seen, quite at the bottom of the cliff. The extent of it visible is small. It makes the impression of being the upper part of a curve or fold of a sheet. If this is so, and supposing the sheets to be contemporaneous and not intrusive, this rock is older than the last described, considerable thickness of sedimentary material intervening. This rock is very schistose. It is highly altered, very little of its abundant felspar having any definite form as compared with the last. Calcite, chlorite and quartz are in large amount, there is also much ilmenite in various stages of alteration to leucoxene, and many of the large patches of chlorite are full of beautiful sagenitic rutile.

Again, passing from the Castle Cove by the path between the mainland and the so-called "island" of Tintagel Head, and descending to the shore below the steep west cliff of the mainland part of the Castle, we come upon a section of several sheets, or bands, of igneous rocks of various thickness, with intervening black shale. The upper sheet is some feet in thickness, then comes a bed of shale in which are two or three sharply separated bands of igneous rock of a few inches only, and finally a lower sheet of which some four to six feet are seen. They are only exposed for a few yards. It is not possible to make out anything with certainty, but very probably the upper portion of this exposure is connected with the rock seen near the waterfall in the Castle Cove.

I have examined specimens from the upper band of the series. It is again a very schistose rock. Microscopically it is interesting because it contains a good deal of what may undoubtedly be considered to be *original* igneous structure. The felspar, very abundant, is partly turbid and partly water-clear, and all the larger individuals are more or less full of flakes of muscovite. Crystal forms are well retained, and twinning, both binary and multiple, is very little obliterated. Tabular crystals are most numerous, but columnar

shapes are also well represented. Besides the large crystals, however, there are a considerable number of much smaller lath-shaped felspars. These are all water-clear, well twinned, and quite fresh as to optic qualities. They all extinguish at very small angles. There is no sign of any original ferro-magnesian mineral, which is now only represented by abundant chlorite. There is much leucoxene; but little sphene or rutile. Broken, bent, and optically strained crystals are in plenty here as in the other rocks.

The two rocks of the Castle Cove may have resulted from the alteration of either massive or fragmental igneous materials; the microscopic study of them does not afford sufficient evidence for decision one way or other. But the structure of the rock just described seems plainly to show that it was a massive one, its numerous larger felspars set in a ground-mass of which the smaller lath-shaped crystals formed part. It was probably a basic rock, though much of its felspar seems now altered, by dynamic metamorphism, to mere acid forms.

The main occurrence of altered igneous rock in this district, however, is on a very much larger scale than any of those above described, and forms, indeed, one of the principal features of the coast at some parts of the parish of Tintagel.

(*To be concluded.*)

III.—On the Ballantrae Rocks of South Scotland and their Place in the Upland Sequence.

By Prof. Charles Lapworth, LL.D., F.R.S., F.G.S.

(With Plate III. and a folding Table extra).

(*Concluded from page* 24.)

Part II.—The Sequence in the Southern Uplands.

NEXT to the metamorphic region of the Northern Highlands there is perhaps no area in Britain where the strata have been so contorted and convulsed as in the great Lower Palæozoic region of the Southern Uplands of Scotland, and it is only by the *zonal* method of stratigraphy that these complexities can ever be successfully unravelled. So far as the present results of the application of that method enable us to judge, it appears that, underlying all these stratigraphical complexities, there is, in reality, a broad tectonic structure of great simplicity. For, if we make exception, on the one hand, of the lowest strata (the *Ballantrae* or *Arenig* rocks), which, as we have seen, only rise to the surface within the limits of the Ballantrae district; and on the other hand of the highest formations (*Wenlock-Ludlow*), which merely skirt the Upland plateau upon its north-west and south-west flanks, we find that almost the whole of the Lower Palæozoic strata of the Uplands are naturally grouped in two grand lithological terranes, viz. (I.) a *Lower Terrane* (*Moffat Terrane*), including strata ranging from the Upper Llandeilo to the Upper Llandovery; and (II.) an *Upper Terrane* (*Gala or Queensberry Terrane*), embracing strata generally of Tarannon age.

The rocks of the Lower or *Moffat Terrane* attain their maximum development in the Ballantrae-Girvan district to the extreme north-west of the Uplands. In this district the terrane is made up of the three successive local rock-formations which have been termed by myself[1] (*a*) the *Barr or Stinchar Series* (of Bala-Llandeilo age), (*b*) the *Ardmillan Series* (of Bala-Caradoc age), and (*c*) the *Newland Series* (Llandovery). Its strata are here very varied in lithological character, contain an abundant fauna of all the usual Lower Palæozoic life types, and have an aggregate thickness which has been estimated at about 4000 feet. Followed thence, however, as they reappear in the many anticlinal forms of the Uplands towards the south-east, they diminish very rapidly in vertical extent, until, when we reach the Moffat district (50 miles to the south-eastward), the strata of the entire terrane are reduced to a collective thickness of 300 or 400 feet. In this district also they have lost their original varied lithological characters, and have dwindled down into a comparatively homogeneous mass of black, grey and white shales: while their diversified fauna has degenerated into one almost exclusively Graptolitic.[2] Nevertheless, in spite of the remarkable attenuation of the strata of the terrane, its three component formations are still recognizable as the three local divisions of the Moffat Series, (*a*) *Glenkiln Shales*, (*b*) *Hartfell Shales*, and (*c*) *Birkhill Shales*. Palæontologically these answer broadly to the three Girvan divisions, the Graptolites characteristic of the lowest Moffat or Glenkiln Shales being equally characteristic of the lowest or Stinchar formation of Girvan: those Graptolites in the second or Hartfell division being found in the second or Ardmillan formation of Girvan: while those of the highest or Birkhill shales agree precisely with the forms characteristic of the third or Newland formation of Girvan. This parallelism is not only evident as respects each of the three successive subfaunas, but many of the subordinate zones in these widely separated districts admit of an equally satisfactory parallelism in sequence and in lithology, as well as in characteristic fossils.[3]

To the south-west of the Moffat district the rocks of the Moffat Terrane soon plunge below strata of more recent age, and are seen no more within the limits of the Scottish Uplands. They must, however, still retain their attenuated and deep-water character for many miles in their subterranean course in this direction; for when they re-emerge in the Lake district (as the *Coniston Limestone Group* and *Skellgill Graptolitic Shales*), their middle members (*Coniston Limestone Series*) have only gained a few hundreds of feet in collective extent, while the strata of their highest division (*Birkhill* or *Skellgill Shales*) are practically unaltered in lithology, thickness, and in fossils.[4]

Graduating upward conformably from the highest beds of the

[1] Lapworth, Girvan Succession, Q.J.G.S. 1882, pp. 537–666.
[2] *Ibid*, Moffat Series, Q.J.G.S. 1878, pp. 240–346.
[3] Compare Tables Q.J.G.S. 1882, p. 660, and 1878, p. 250.
[4] Marr and Nicholson, Q.J.G.S. 1888, pp. 706–708.

GEOLOGICAL SECTIONS THROUGH THE

Fig 1. Eastern Districts. E

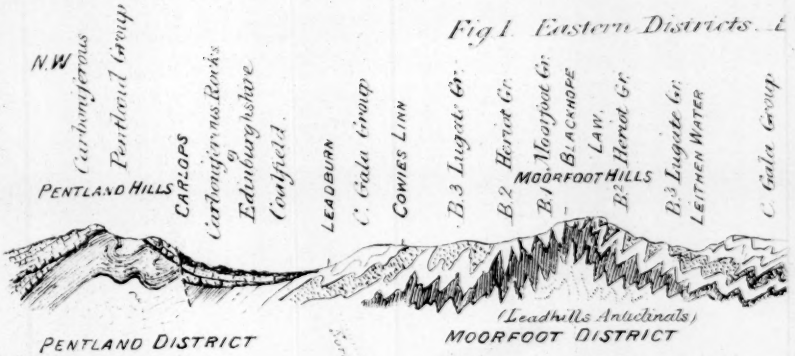


FIG. 2. Central

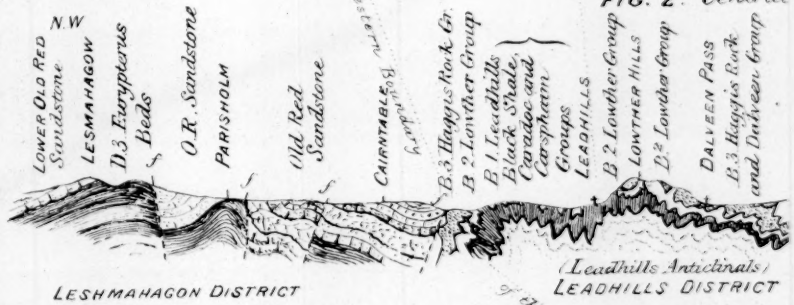


FIG. 3. Western Distri

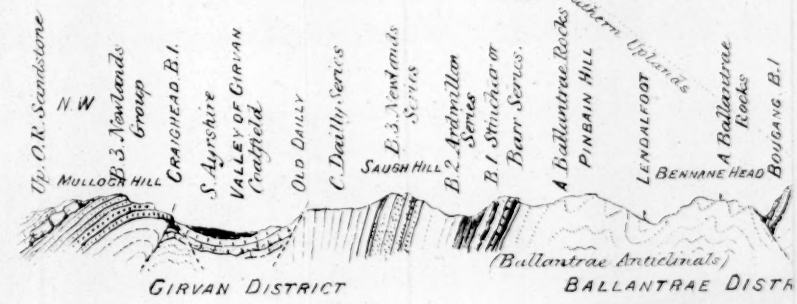
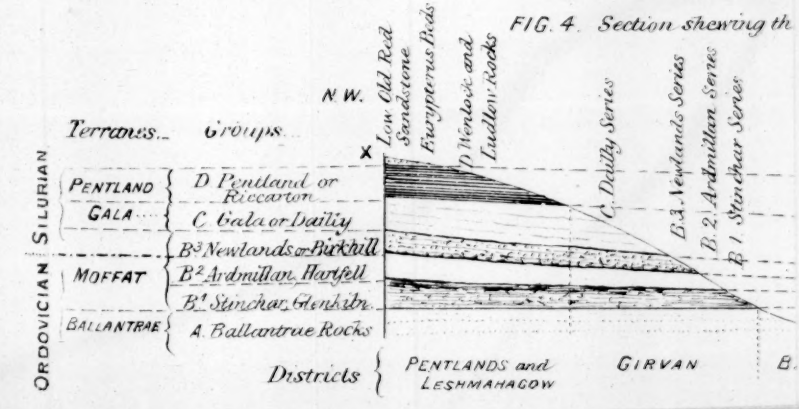


FIG. 4. Section shewing th



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[4] Marr and Nicholson, Q.J.G.S. 1888, pp. 706–708.

GEOLOGICAL SECTIONS THROUGH THE LOWER PALÆOZOIC ROCKS OF THE SOUTHERN UPLANDS OF SCOTLAND

By C. Lapworth 1888.

Fig 1. Eastern Districts. EDINBURGHSHIRE, PEEBLES, SELKIRK and ROXBURGH (40 miles)

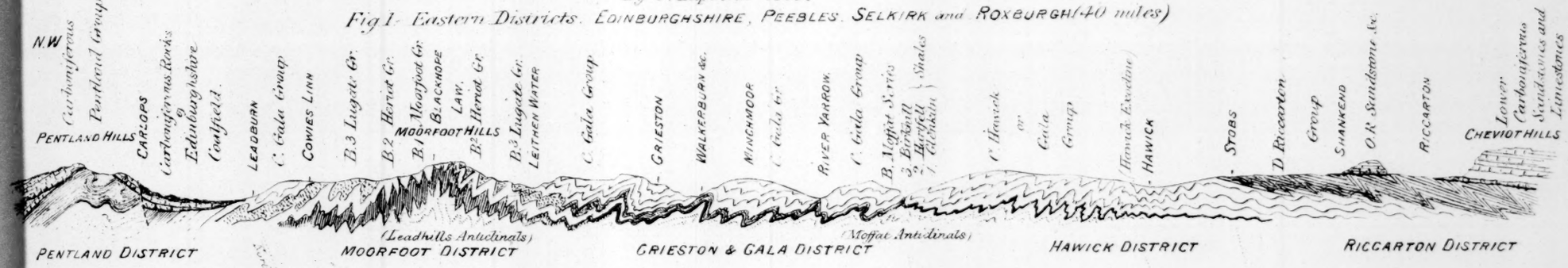


FIG. 2. Central Districts - LANARKSSHIRE and DUMFRIESSHIRE

FIG. 3. Western Districts - AYRSHIRE and WIGTONSHIRE

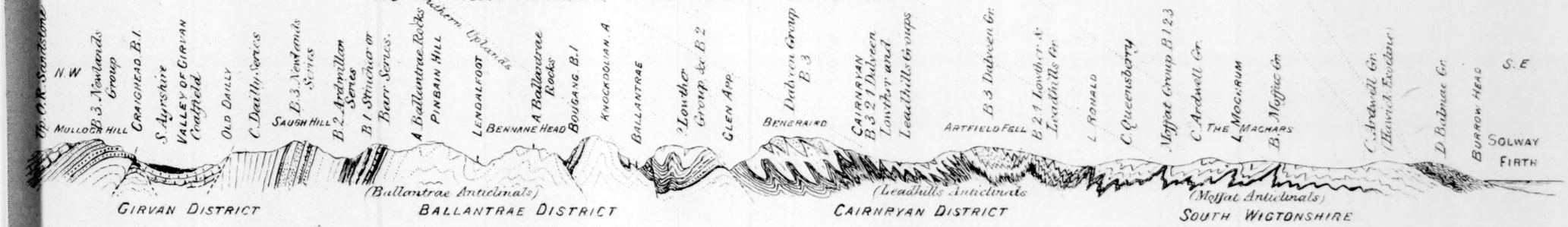
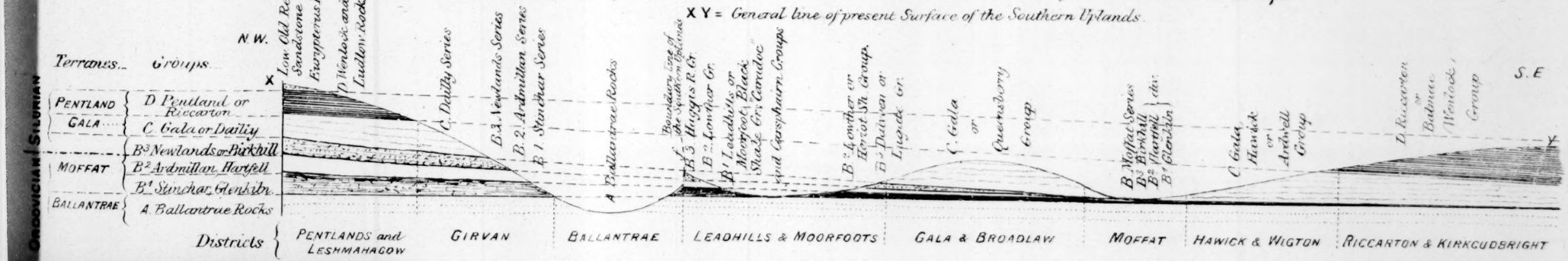


FIG. 4. Section shewing the Sequence, Correlation, Relative thicknesses and Local titles of the S. Scottish Rock-Groups.

XY = General line of present Surface of the Southern Uplands.



West, Newman & Co. imp.

Moffat Terrane in the Scottish Uplands we find the grand mass of more or less barren flagstones, shales, and greywackés which make up the overlying *Gala* or *Queensberry Terrane*. In the Girvan district the rocks belonging to this terrane form the local *Dailly series*,[1] and are about 2500 feet in thickness, consisting mainly of repetitions of gray grits, flagstones, and red, green and purple shales. The Graptolitic fauna of the terrane is more or less transitional in character. Several forms are certainly peculiar to the Gala beds, but the older zones contain many survivors of the Moffat (*Birkhill*) fauna, while the higher zones yield several species which recur in the overlying *Riccarton* (Wenlock) rocks. The strata of the Gala Terrane grow somewhat thicker and coarser as they are followed eastward from Girvan over the Uplands, and fossils become rarer; but even in the central parts of the plateau (Dumfriesshire and Selkirkshire) a *lower* (Queensberry) and a *higher* (Grieston) division can still be roughly made out. Followed, however, still farther to the south-eastward, the rocks of the terrane soon imitate the example of the underlying Moffat series, becoming much finer in grain and decreasing in thickness. Finally, the whole terrane plunges in this direction (Hawick, etc.) below the Wenlock rocks of Riccarton and Kirkcudbright, and when it re-emerges in the Lake district, it has dwindled down to an attenuated series of coloured shales and flags (*Browgill* or *Pale Shales*) with a collective thickness of less than 300 feet.[2] Even here, however, its strata are still marked by the same two transitional subfaunas as those of the great *Gala Group* of the Scottish Uplands.

We find, therefore, that while the South Scottish strata of the *Moffat Terrane* are reduced to nearly a tenth of their original thickness within a comparatively short distance (25 to 50 miles) of the Girvan district, the thickness of the massive Gala Terrane remains practically undiminished over most of its visible range in the Scottish Uplands, and is even augmented in the central parts of the plateau. Hence in spite of its greatly inferior systematic importance, the Gala Terrane has a collective thickness over the Upland region far in excess of that of the underlying Moffat series. It follows, as a natural consequence of this fact, that when we regard the Upland region from the structural or tectonic point of view, we find the main mass of its visible rocky floor is formed of the rocks of this great greywacké or *Gala terrane*. This has been crushed into innumerable wrinkles and puckers; the strata of the underlying *Moffat* series rising to the surface only along some of the larger anticlinal forms. As in other convoluted regions, the vast majority of these folds are of the class known as *overfolds* or *inverted folds*,—the axial plane of each fold being more or less inclined to the horizon; and thus the apparent dip of the truncated strata seen in section gives no clue whatever to the natural succession of the beds. But for many years it has been acknowledged on all hands that these overfolds are broadly related in position to two main struc-

[1] Q.J.G.S. 1882, p. 659.

[2] Marr and Nicholson, Q.J.G.S. 1888, pp. 674–678, etc.

tural lines, to which their axial planes strike more or less parallel, along which they are practically perpendicular, and *from* which, or *to* which, they slope as we pass outwards in opposite directions. These neutral lines run longitudinally (but somewhat obliquely) through the Upland region from sea to sea. The southern line sweeps from St. Abb's Head past Hawick and Dumfries towards the Mull of Galloway, and the northern line from Dunbar through the Lammermuir and Moorfoot Hills, past Lead Hills and Carsphairn to the sea near Port Patrick. From the opposite sides of the Southern (*Hawick line*) the axial planes of the parallel overfolds slope *outwards* to the south-east and north-west, the axes of the two opposed sets of folds having been pushed over in opposite directions upon the neutral line. Along the opposite sides of the northern (*Lead Hills*) line the axes of the inverted folds usually dip *inwards*, the axial planes of the two opposed sets of folds sloping obliquely outwards above from off the neutral line. In this second case (Lead Hills line) we have clearly nothing more than the ordinary "fan structure" of mountain areas. In the first case (Hawick line) we have merely the "fan structure" inverted. I have discussed elsewhere[1] the stratigraphic significance of these forms in mountain areas generally, and have shown that we must naturally expect to find the deepest strata in the "fan structure" (*endocline*) or pseudo-synclinal form and the highest in the folds of the inverted fan structure (*exocline*) or pseudo-anticlinal. These deductions are strikingly exemplified in the present instance. The whole of the Gala terrane has been swept off for some miles on both margins of the Lead Hills pseudo-synclinal, and the locally thick Moffat terrane, which is there some thousands of feet in vertical extent, has been eroded almost to its base. Along the Hawick pseudo-anticlinal, on the contrary, the rocks of the Moffat terrane are wholly buried from sight, while the Gala terrane is present from base to summit, and subsides to the southward under the still higher group of the Riccarton and Balmae series (the Upland equivalents of the Wenlock and Lower Ludlow strata of Siluria).

Roughly parallel with these two neutral lines (or axes of axes), to others less perfectly defined, and also to several gigantic strike-faults, the strata of the Scottish Uplands are ridged up into overfolds of all degrees of importance and complexity, from the crests of which the rocks of the Gala terrane, in many cases, have been removed, and the strata of the underlying Moffat terrane laid bare. The exposures of these pre-Gala strata usually occur in more or less connected areas, in broad boat-like patches, or in narrow disconnected moniliform lines. These are disposed in broad geographical bands or zones which range longitudinally through the district parallel with the chief axial lines. Three of these bands are especially conspicuous: (1) the S.E. band of Wigtown, Moffat and Melrose (*Moffat-Melrose band*), (2) the central band of Port Patrick, Lead Hills and Lammermuirs (*Lead Hills—Moorfoot band*), and (3) the western zones of *Ballantrae* and *Girvan*. Each of these bands is in

[1] Lapworth, Geol. Mag. 1883, p. 138, etc.

reality the locus of a complex anticlinal form, whose component simple folds have been crushed together, overthrust, and irregularly denuded. As we pass from the Moffat area to the north-eastward, we find that each of these compound anticlinals increases in length, depth, and systematic importance. In the anticlinal forms of the first band (*Moffat-Melrose*) the exposures of the strata of the Moffat rocks appear as narrow inliers in the locally ended Gala terrane, and are at the most a score or two of yards in width; while the total thickness of the pre-Gala rocks exposed (Birkhill to Glenkiln) is only from 300 to 400 feet. In the anticlinal forms of the second band (*Lead Hills—Moorfoot*) the exposure of the pre-Gala rocks are often more than a mile in diameter; and the strata of the locally thick Moffat Series are occasionally laid bare to a depth of at least two thousand feet, down to the calcareous strata at their base (Duntercleuch and Wrae Hill). Finally, in the most westerly anticlinal forms (those of *Ballantrae and Girvan*) the exposures of the pre-Gala rocks are four or five miles across; and, as we have seen, not only is the locally massive Moffat series exposed from summit to base (4000 feet), but even the underlying Ballantrae or Arenig rocks are laid bare, as far down as the horizon of the Skiddaw Slates.

In the complex synclinal zones, between these complex anticlinal zones, the rocks of the Gala terrane form broader parallel bands sweeping longitudinally through the Uplands from sea to sea. The widest bands are those ranging along the exocline (Hawick line) already described, and those of Gala, Broadlaw, and Queensberry. These bands, however, are all united into a more or less continuous sheet, the Moffat exposures which locally divide them being usually of small longitudinal extent. The Gala beds, on the other hand, which occur north of the main Lead Hills anticlinal (*endocline*), as at N.W. Peebles, L. Doon, Girvan, etc., are usually disconnected, narrower, and of minor importance.

The component formations of the underlying *Moffat terrane* are frequently well exhibited along the eroded crest of the intermediate anticlinal bands between the more or less continuous sheets of Gala rocks, and their gradual change in thickness, lithology, and palæontology can be followed, stage by stage, as we pass from place to place, and from fold to fold.

Commencing with the most southerly, or Moffat-Melrose band, we find that in the typical area of the Moffat district we have merely the three Graptolitic zones of the Glenkiln, Hartfell and Birkhill, forming a comparatively homogeneous mass of grey and black shales and mudstones. Followed, however, even along the line of strike to the north-west, towards Selkirk and Melrose, the beds thicken, and bands of grit, flagstone, and conglomerate come in between the shale zones in definite and recognizable order. But when followed at right angles to the strike from S.E. to N.W. transversely across the Uplands, the change is very much greater. The entire series thickens rapidly, and the black shale bands are replaced one by one from above by barren flagstones and shales,

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similar in all their lithological features to those characteristic of the overlying Gala terrane.

Proceeding still farther in this north-westerly direction to the grander anticlinal forms of Carsphairn, Wenlockhead, Moorfoot Hills, etc., we find the Moffat Series represented by a great thickness of grey shales, flagstones, greywackés, and fine conglomerates, with occasional black shale zones (which are most numerous near the base of the series), the whole being intermediate in geographical position, in thickness, in lithological features, and in palæontological characters between the attenuated Moffat Series to the S.E. and the magnificent development of the same terrane in the Girvan region to the N.W. In these intermediate anticlinal forms we can rudely distinguish three main rock-groups, which are, however, so convoluted and interfolded that their details are as yet only partly worked out, their thickness is unsettled, and their boundaries ill defined. In the cores of the main anticlinal forms of the Lammermuir-Moorfoot area we find (1) a group of grey and black shales, with flinty bands, grits, and conglomerates (*Moorfoot Group*), the inner zones of which yield the Graptolites of the Glenkiln Shales, and the outer bands those more characteristic of the Lower Hartfell. Outside this group follows (2) a thick series of more or less barren grey flagstones, shales, grits (*Heriot Group*), which seems to answer in position and character to the barren beds of the Upper Hartfell. Finally, between these barren shales and the base of the Gala terrane, we recognize a third group (3) (*Lugate Group*) of grey shales, flagstones, and conglomerate (? *Haggis Rocks*), with rare fossil-bearing bands, yielding some of the characteristic Graptolites of the Birkhill Shales. In the anticlinal forms of the Lead Hills, Carsphairn and Shinnelhead districts to the south-west, as shown by the published Maps[1] and Explanations of the Geological Survey, the same geographical and geological grouping is discernible. The local *Dalveen and Haggis Rock Group* of that region come into the place of the Lugate Series, the *Lowther Group* apparently into the position of the Heriot Series, while the *Leadhills Black Shales* correspond in place and fossils with the Moorfoot Series. But as these south-westerly anticlinal forms are of greater diameter, and lie many miles nearer to the Girvan District, there appear, in addition, within the limits of the Leadhills Shale Group, representatives of the lowest Moffat strata of the Girvan area in the form of the Brachiopod-bearing limestones, grits, conglomerates of Wrae Hill, Duntercleuch, and Glendowran.[2]

Finally, when we reach the most distant group of anticlinal forms —those of the Girvan-Ballantrae District itself—the lithological and palæontological modification of the typical Graptolitic Moffat Series is complete, and the terrane is represented by the three rock-formations already referred to, which are as richly varied petrologically and zoologically as are their equivalents in the well-known districts of Wales and the West of England.

[1] Compare Maps 15, 9, 3, 4, etc. and the accompanying Explanations, Geol. Survey, Scotland.

[2] Explan. Sheet 15, p. 14, etc.

Such I have long held to be the general structure and succession of strata[1] of the Lower Palæozoic region of the Southern Uplands, as deduced from the facts and conclusions essentially dependent upon the zonal method of stratigraphy. Upon this view the sequence, lithology and palæontology of the several recognizable zones of strata in the Upland region become mutually intelligible, and the various rock-formations and their fossils admit of satisfactory parallelism with those of the corresponding Proterozoic deposits of other districts both in Britain and abroad. See the accompanying table on page 66.

It may be objected by some of those geologists who are familiar with the literature of discovery and speculation among these South Scottish rocks, that these views are opposed to those advocated by previous observers.[2] But I believe that this opposition is more in appearance than reality. The physical facts and phenomena upon which the earlier views of the succession were based remain unquestioned. They are here, however, supplemented by the conclusions drawn from the abundant stratigraphical and palæontological discoveries of the last fifteen years, and have received the only interpretation which seems to me to be possible in the present state of our knowledge. We have to recollect that all the earlier views of the succession were based almost exclusively upon the very natural theory that the Hawick-Dumfries axis is a true anticlinal form, and the Sanquahar-Moorfoot axis is a true synclinal, propositions upon which no one familiar with our actual knowledge of the stratigraphical phenomena of mountain regions would at the present day place the least reliance; while at the time when the very latest of these earlier schemes was published, the paramount value of the Graptolite as a geological index was unknown and unsuspected. The lithological "groups" of these earlier and local classifications fall naturally into their proper places in the present scheme, and find their simple interpretation as successive geographical bands in the same great Lower Palæozoic succession as it slowly changes in thickness and lithology when followed from the shore line into deeper water: while, under this arrangement, their formerly conflicting Graptolitic faunas show the same sequence they hold over the rest of the Lower Palæozoic world. The present views have also this further recommendation that they depend upon, and necessitate, the harmony of all the ascertainable phenomena—geographical position, thickness, lithology, local sequence, and palæontology—and admit of being tested in each of these characters in the field at every stage, and of being confirmed, extended and corrected as discovery progresses.

But although I hold that all the known facts and phenomena bearing upon the sequence of the rocks of the Southern Uplands

[1] Compare Lapworth, Transactions Geol. Soc. Glasgow, 1878, pp. 78 to 84, etc.

[2] Sedgwick, 1849, Rep. Brit. Assoc. p. 103; Nicol. Q.J.G.S. 1850, p. 53; Murchison, ibid. 1851, p. 137; Siluria, 4th edition, pp. 148–158; A. Geikie, Trans. Geol. Soc. Glasgow, 1867, p. 74; Explan. Sheet 3, Geol. Survey Scotland, 1873, pp. 4–18; ibid. sheet 15, p. 9, etc.

[To Illustrate Prof. C. Lapworth's Paper on the Ballantrae Rocks of South Scotland and their place in the Upland Sequence, Geol. Mag. Decade III. Vol. VI. No. 2.]

TABLE I.

SHOWING THE GENERAL SYNONYMY OF THE UPLAND ROCK-GROUPS.

Terranes.	Ayrshire, etc.	Lanarkshire, etc.	Edinburghshire, etc.	Selkirk & Roxburgh.	Dumfries and Kirkcudbright.	Lake District.	West of England.	
D. Pentland. Terrane		Lesmahagow Beds.	Pentland Beds.			Kirkby Moor Flags, etc.	Upper & Middle Ludlow.	Silurian.
				Riccarton Series.	Balmae Group.	Coniston Grits and Flags, etc.	Lower Ludlow and Wenlock.	
C. Gala Terrane	Dailly Series.	Queensberry Gr.	Gala Group.	Hawick Group.	Ardwell Group.	Browgill Beds.	Tarannon.	
B. Moffat Terrane B. 3	Newlands Series.	Dalveen & Haggis Rock Group.	Lugate Group.	Birkhill Shales.		Skellgill Shales.	Llandovery.	
B. Moffat Terrane B. 2	Ardmillan Series.	Lowther Group.	Heriot Group.	Hartfell Shales.	Moffat Shales.	Coniston Limestone Group.	Caradoc.	Ordovician.
B. Moffat Terrane B. 1	Stinchar or Barr Series.	Leadhills Black Sh. Carsphairn, and Caradoc Groups.	Moorfoot Group.	Glenkiln Shales.		Borrowdale Volcanic Series.	Llandeilo.	
A. Ballantrae Terrane.	Ballantrae Rocks.					Skiddaw Slates.	Arenig, etc.	

can only be harmonized upon the lines here laid down, it must be frankly admitted that, in spite of all that has been already accomplished, our knowledge of these strata is still in its infancy. We have so recently become aware of the proper methods of attacking the many geological problems they present for solution, that the most interesting and complicated part of the work yet remains to be done; and those geological students who have made themselves familiar with the new developments of our knowledge of the older rock-formations will find this South Scottish region a fruitful field for original research. My own intermittent labours for the last twenty years in this great plateau (which covers an area of at least 5000 square miles) have been only sufficient to permit of my working out in detail the sequence in the two contracted areas of Moffat and Girvan, and of studying in much less minuteness a sufficiency of the test districts elsewhere to enable me to feel assured of the general truth of the views here developed. It remains for others, and especially for local geologists, to verify and to apply these views to the detailed mapping of the Uplands generally.

In the palæontological part of this work the *Graptolites* must, of necessity, play the chief *rôle*, for they are almost the only fossils met with in the strata of this wide region. But the *minor* stratigraphical conclusions to which those fossils point ought not to be overstrained, but should be tested and re-tested upon every available opportunity. We cannot expect to recognize from end to end of the Uplands all the minuter "zones" of Moffat, Girvan, Skellgill or Scania; but we ought certainly to be able to identify by their means all the major stratigraphic subdivisions. Nothing more can be claimed for the Graptolites than that which is claimed by all geologists for the corresponding species of Trilobites or Ammonites. Each formation has its characteristic Graptolitic species and varieties, and each species has a certain fairly known vertical range in the detailed sequence of the Lower Palæozoic rocks;[1] while the invariable association of special forms in beds of corresponding systematic position affords a presumptive palæontological index of the true systematic place of strata marked by the same forms elsewhere. With this we must rest content; but even here I hold we have sufficient palæontological criteria, when checked and aided by all the available local stratigraphical evidences, to enable us to map out, in time, the Lower Palæozoic rocks of the Uplands in all their main geological subdivisions.

The known restriction of the entire family of the *Monograptidæ* to Silurian strata, and its absence from Ordovician rocks, affords us the means of determining the outcrop of the Upland boundary-line between the Ordovician and Silurian deposits; and the laying down of this line will give us the first useful geological map of the region. Next must follow the tracing of the less important divisional lines at the bases of the Glenkiln (Upper Llandeilo) and Hartfell (Caradoc) Groups in the Ordovician, and those at the summits of the Birkhill (Llandovery) and Gala (Tarannon) Series of the Silurian. Not

[1] Lapworth, Geol. Dist. Rhabdophora, Tullberg, Skånes Graptolither, etc.

until this work has been accomplished, and the Scottish Arenig, Wenlock and Ludlow strata studied in equal detail, can we claim that our knowledge of the geological structure of the Scottish Uplands is even fairly complete.

But, if the ideas expressed in this paper are well founded, the main results of future investigations, in so far as they affect the general mapping of the Upland area proper, can even now be sketched in outline. The *Axial* or *Ardwell* Group of the earlier investigators will disappear as a separate series, and will take its place as the southerly extension of the Gala or Queensberry Group to the north. The *Dalveen* (and Haggis Rock) (*Lugate Series*); the *Lowther Group* (*Heriot*), and the *Leadhills Black Shale* and *Caradoc* and *Carsphairn Group* (*Moorfoot Series*) will all be found to be regional geological complexes of a thickness far inferior to that with which they have hitherto been credited; but, nevertheless, each possessing a high local value, as significant of the local peculiarities and intermediate lithological condition of the Moffat Terrane in the central districts. These three "central" groups, when worked out in detail and restricted to their natural components, will be found to follow each other in the order given above:—the Dalveen-Lugate Group answering to the Birkhill Shales, the Lowther-Heriot Group to the Hartfell (Upper, etc.), while the strata of the Leadhills-Moorfoot Group must be re-arranged, and will fall, part into the Lower Hartfell (Caradoc), and part into the Glenkiln (Upper Llandeilo) formations.

The general geological map of the Uplands will show that the rocky floor of that region is composed of strata ranging almost from the base of the Ordovician up to the summit of the Silurian. The outcrop of the main boundary-line between the strata of the two systems (which is on or about the horizon of the so-called Haggis Rock) will be found to pass obliquely across the region from the north-east margin of the Uplands near Dunbar, over the crest of the Lammermuirs, to the south of the Moorfoots, and north of the town of Peebles, over the valley of the Tweed near Neidpath and the Crook, into the valley of the Clyde near Elvanfoot; and thrown next to the southward by the anticlinal of the upper reaches of the Shinnel, will be found to cross the southern part of the granitic range of the Kells towards the sea-coast south of Portpatrick. To the north and north-east of this guiding line the mass of the strata will be proved to be *Ordovician;* such Silurian rocks as occur forming outliers parallel with the great boundary fault. To the south-east of the divisional line the mass of the strata must be classed as *Silurian*; the Ordovician rocks only occurring locally as long lenticular inliers gradually diminishing in systematic importance as they are followed across the country from north to south, and from west to east.

Of the Upland "formations," the *Arenig* appears to have the smallest superficial extent, its outcrops being as yet confined to the Ballantrae region (unless indeed some of the so-called Old Red Sandstone near the boundary-line is of this age): the true *Caradoc* will be mapped as narrow boat-like sheets along the greater anticlinal

forms — surrounding included and narrower bands of Llandeilo rocks, and enveloped in turn by still broader sheets of Llandovery strata, etc. The great *Gala* (*Tarannon*) terrane must be coloured as the prevailing visible rock-mass of the Uplands, sweeping along the central and southern parts of the plateau in a broad sheet (from 20 to 25 miles in width) from the North Channel to the German Ocean, only interrupted locally by long and narrow lenticles of pre-Gala rock, which decrease both in number and importance as we pass from south-west to north-east. Finally fringing the Gala Terrane along the south-east flanks of the Uplands from Burrow Head to the Cheviots will follow in natural superposition the slowly widening band of the *Wenlock Ludlow* (Riccarton) beds, the boundaries of which have been already sketched out by the officers of the Geological Survey.

In the accompanying Plate (Plate III.) I have given some sketch-sections across the Upland region illustrative of my views of the general disposition and inter-relationships of its strata; and in the following "Table of Correlation" will be found incorporated some of the more important palæontological data which bear upon the question of the Upland Sequence. (See Folding Table II.)

IV.—On Local Thickening of Dykes and Beds by Folding.

By Alfred Harker, M.A., F.G.S.,
Fellow of St. John's College, Cambridge.

In his "Geology of North Wales" (p. 102, 2nd ed.), Sir A. Ramsay figures a vertical cross-section of a greenstone dyke, which he describes as running along the cleavage-planes of the slate in the Ffestiniog quarries, and alternately "bulging and thinning off in a rapid succession of oval-shaped masses of 3 or 4 feet in length." He seems to imply that this is one of the dykes posterior to the disturbance which produced the cleavage of the district. The ordinary post-Carboniferous dykes of North Wales, however, strike nearly at right angles to the cleavage; and further it is not easy to imagine any circumstances attending the intrusion of this one that would account for the phenomenon of alternate thickening and attenuation described. A precisely similar peculiarity is to be seen in 'Dew's quarry' at Pen-y-bryn, Nantlle. The same thing is figured by Lehmann ('Altkrystallinischen Schiefergesteine,' pl. xiii. fig. 4) from granite-veins in the Saxon granulites.

At several places in the Cambrian *massif* of Rocroi, notably north of Mairus near Monthermé, beds of grit intercalated among the slates are seen to swell and contract in the same manner. Their thickness at the ventral segments is usually at least double of that at the nodes. The distance between the nodes seems to depend on the thickness of the bed. Gosselet has recently given a photograph of this 'almond-like' arrangement of the 'quartzites' in his great memoir on the Geology of the Ardenne. In these cases, at least, since we have to deal with sedimentary strata, it is clear that the

TABLE II.

SHOWING THE CORRELATION AND BRITISH EQUIVALENTS OF THE LOWER PALÆOZOIC ROCKS OF THE SOUTH OF SCOTLAND.

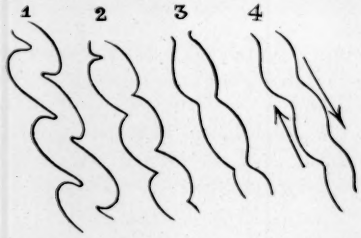
		LOCAL TYPES OF THE SOUTH SCOTTISH DEPOSITS.				SOUTH BRITISH EQUIVALENTS.	
		North-Western District. Ayrshire (Girvan and Ballantrae).	West Central District. Lanark, N. Dumfries, N. Kirkcudbright, N. Wigton, etc.	East Central District. Edinburgh, Peebles, N. Selkirkshire.	South-Eastern District. Roxburgh, S. Selkirk, Central Dumfries, S. Kirkcudbright, Wigton.	Lake District.	Wales and the West of England.
SILURIAN.	Pentland Terrane. Upper.		Lesmahagow Flags and shales, graduating downwards from Old Red Sandstone. Fossils:—*Eurypterus, Slimonia, Pterygotus.*	Upper Pentland Sandstones shales and grits, with abundant Ludlow fossils.		Kirkby Moor Flags and sandstones, with Ludlow fossils.	Upper and Middle Ludlow Formations of Salop and Hereford.
	Pentland Terrane. Lower.			Lower Pentland Flagstones and shales, with *Monogr. vomerinus, Retiolites Geinitzianus.*	Riccarton Flags and Shales of Langholm, Riccarton, Balmae, etc., with *M. colonus, M. priodon, M. Flemingii,* etc.	Bannisdale Slates, etc., Coniston Grits and Flags, with *M. colonus, M. Flemingii, M. vomerinus,* etc.	Wenlock and Lower Ludlow beds of Salop, and Denbighshire Grits with *M. colonus, M. vomerinus,* etc.
	Gala Terrane.	Dailly Series of Girvan District. (*c*) Straiton Beds, with *M. personatus,* etc. (*b*) Bargany Beds, with *Monogr. acus.* (*a*) Penkill Group. (2) *Upper* Flags, Grits and Mudstones, with *Retio. Geinitzianus, Cyrtograptus Grayæ,* etc. (1) *Lower* purple shales, flags and grits, with *M. exiguus, M. crispus, Protovirgularia, Crossopodia,* etc. Newland Series (Girvan).	Queensberry Group of N. Dumfriesshire, Kirkcudbright, and S. Wigtonshire: with *Crossopodia, Protovirgularia,* etc.	Gala Group of S. Edinburgh, Selkirk and Peebles. 2. *Higher beds.*—Grieston flags and shales, with *R. Geinitzianus, C. ? spiralis, M. priodon,* etc. 1. *Lower beds.*—Gala grits and coloured mudstones, with *M. exiguus, M. crispus, Protovirgularia, Crossopodia,* etc.	Hawick Rocks of Roxburgh, Selkirk, etc., with *Proto. virgularia, Crossopodia,* etc. } Ardwell Group of Dumfriesshire, Kirkcudbright, etc. with *Proto. virgularia, Crossopodia,* and *Monograptidæ.*	Browgill Beds (pale slates). (*b*) *Upper Beds* (barren). (*a*) *Lower Beds,* with zones of 2. *Monogr. crispus, R. Geinitzianus,* etc. 1. *M. turriculatus, M. exiguus,* etc.	Tarannon Shales of Tarannon and Llanbrynmawr. 2. *Middle Zone* with *R. Geinitzianus, Cyrto. Grayæ,* etc. 1. *Lower Zone* with *M. turriculatus, M. exiguus,* etc.
	Moffat Terrane (*continued*). Upper Division.	(*c*) Camregan *grits,* limestones, shales, etc., with *Pentamerus oblongus, Rastrites maximus, M. turriculatus,* etc. (*b*) Saugh Hill Group. 3. Flags and shales, with *M. spinigerus, M. distans,* etc. 2. Grits and shales, with *M. gregarius, M. fimbriatus, Rastrites peregrinus.* 1. Woodland conglomerates, flags and shales, with *Pentamerus lens, M. cyphus, M. revolutus, Dimorphograptus,* etc. (*a*) Mulloch Hill Group. Sandstones, shales and conglomerates, *Meristella angustifrons, Diplo. acuminatus, Monogr.* sp.	? Part of Queensberry Group. Dalveen and Haggis Rock Group.	Lugate Group. 4. Shales, flags, and grits of Walkerburn, etc., with *Rastrites maximus,* etc. 3. Flags, black shales, and grey shales of Trowier Burn, with *M. spinigerus,* etc. 2. Conglomerate, grits, flags and shales of Sit Burn, etc., with *M. gregarius, R. peregrinus,* etc. 1. Conglomerates, grits and shales of Channelkirk, (Leader) and Still Burn (Lugate), with *Diplo. acuminatus,* etc.	Birkhill Shales (Moffat, etc.). Upper: 3. Zone of *R. maximus, M. turriculatus,* etc. 2. Zone of *M. spinigerus, M. distans,* etc. 1. Bands of *M. Clingani,* and *Petalogr. cometa,* with *M. crenularis, R. hybridus,* etc. Lower: 3. Zones of *M. gregarius,* with *R. peregrinus,* etc., *M. fimbriatus, M. convolutus.* 2. Zone of *Dip. vesiculosus,* with *M. cyphus, M. tenuis.* 1. Zone of *Dip. acuminatus,* with *Dimorph. elongatus ? Monogr.* sp.	Skellgill Beds. *Upper Skellgill Zones.* 3. *Rast. maximus.* 2. *Mon. spinigerus.* 1. *Mono. Clingani. Lower Skellgill Zones.* 5. *M. convolutus.* 4. *M. argenteus.* 3. *M. fimbriatus.* With *M. gregarius.* 2. *Dimorph. confertus, Dip. vesiculosus, M. tenuis.* 1. *Diplo. acuminatus, M. revolutus, Dimorph. elongatus.*	Llandovery Beds of Cardiganshire and valley of the Dee, with *Rast. maximus, Rast. peregrinus, M. Clingani, M. cyphus, M. Sedgwicki* (*spinigerus*), *M. convolutus, Clima. normalis, Diplograptus folium,* etc.
ORDOVICIAN.	Moffat Terrane. Middle Division.	Ardmillan Series. 7. Drummuck Beds. Grey shales. (*b*) Upper zones, with *Staurocephalus globiceps.* (*a*) Lower zones, with *Trinucleus, Asaphus, Dionide, Dicellograptus anceps, Diplo. truncatus.* Shalloch Flagstones and Shales, *Diplo. truncatus, Nematolites.* Whitehouse Beds. (*b*) Grey and coloured flags and shales, with *Dionide, Ampyx, Asaphus,* etc. *Dicello. complanatus, Dip. socialis.* (*a*) Black and grey shales and flags, with *Lepto. flaccidus, Diplo. foliaceus, D. quadrimucronatus, C. tubuliferus.* Ardwell Beds. (*b*) *Upper* flags, shales and grits, with *Dicello. Forchhammeri, Dicrano. ramosum, Clima. caudatus.* (*a*) *Lower* flags and shales, with *Crypto. tricornis, Dip. rugosus, Lasiogr. Harknessi, Clim. Scharenbergi.*	Lowther Group of S. Lanark, N. Dumfries, Kirkcudbright, etc. Grey flags, shales and felspathic grits, usually destitute of fossils.	Heriot Group of S. Edinburgh, N. Peebles, Haddington. Grey flags, shales and conglomerates of Ladyside Burn, Blackhope Burn (Heriot), etc. *Climaco.* sp., *Diplo.* sp.	Hartfell Shales (Moffat, etc.) *Upper Hartfell,* 3. Zone of *Dicello. anceps, D. truncatus, C. scalaris.* 2. *Barren Mudstone.* 1. Lowest zones of the Barren Mudstone zone of *Dicello. complanatus, Dictyonema Moffatensis.*	Coniston Limestone, Dufton Shale, and Ashgill Shale Groups of Lake District.	Upper Caradoc, Central Shropshire, with *Trinucleus concentricus, Orthis Actonia,* etc., *Diplo. foliaceus, D. truncatus.*
		Ardwell Beds. (*b*) *Upper* flags, shales and grits, with *Dicello. Forchhammeri, Dicrano. ramosum, Clima. caudatus.* (*a*) *Lower* flags and shales, with *Crypto. tricornis, Dip. rugosus, Lasiogr. Harknessi, Clim. Scharenbergi.*	Lead Hills or Upper Black Shale Group (in part). Black, grey and ribbed shale, flags, and grits of Lead Hills, St. Patrick, with *Dicello. Forchhammeri, Crypt. tricornis, Lasio. Harknessi, Dicrano. ramosus.*	Moorfoot Group (in part). Grey and black shales and flags with ribs of siliceous and felspathic grit, and bands of coloured sandstone and conglomerate. *Higher zones* (Headshaw zones), Moorfoot Hills, Headshaw Burn, Friars Nose, Lugate Head, etc., with *Dip. foliaceus, Dicello. Forchhammeri, Dicrano. ramosus, Pleurogr. linearis,* etc.	*Lower Hartfell.* 3. Zone of *Pleuro. linearis,* with *Lepto. flaccidus, Diplo. foliaceus, Cl. tubuliferus.* 2. Zone of *Dicrano. Clingani,* with *Clima. caudatus, C. bicornis, D. Forchhammeri, Dicrano. ramosus.* 1. Zone of *Clima. Wilsoni,* with *Crypt. tricornis, Diplo. rugosus, Lasio. Harknessi, Clima. Scharenbergi.*		Lower Caradoc Beds of Western Shropshire. *Aldress Beds,* with *Diplo. foliaceus, Diplo. rugosus, Clima. bicornis, C. Scharenbergi, C. caudatus, Dicello. Morrisi, Dicrano. ramosus.*
	Moffat Terrane. Lower Division.	Barr or Stinchar Series. 5. *Balclatchie Grits,* flags and shales, with *Dicrano. rectus, Glosso. Hicksii, Clima. tricornis,* etc. 4. *Barr. conglomerate.* 3. *Didymograptus Shales,* etc., with *Didymo. superstes, Dicello. sextans, Diplo. euglyphus, Clathrograptus.* 2. *Stinchar Limestone* with *Maclurea Logani, Ophileta compacta, Tetradrium Peachii, Leptena sericea,* etc. 1. *Purple Sandstones,* flags, and conglomerates, with *Orthis confinis,* etc.	Lead Hills Black Shale (in part), together with the *Caradoc* and *Carsphairn Groups* of Lead Hills, Sanquahar and Carsphairn. Fossils: — *Didymo. superstes, Dicellogr. sextans, Dip. euglyphus, Dip. mucronatus, Cænogr. gracilis, Dicrano. rectus,* and Llandeilo-Bala Brachiopoda.	Moorfoot Group (in part). (*b*) *Lower zones* (Browbeat Zones) of Browbeat water, Blackhope, Corsehope, etc., with *Didy. superstes, Cæno. gracilis, Dicello. sextans, Glossogr. Hicksii,* etc.	Glenkiln Shales (Moffat, etc.) Black, grey, and coloured shales and mudstones, with ashy sandstones, and felspathic and siliceous ribs. Fossils:—*Didymogr. superstes, Cænograptus gracilis, Dicello. sextans, Dicello. divaricatus, Diplo. mucronatus,* etc.	Borrowdale Volcanic Series.	Upper Llandeilo of Rorington (W. Salop), with *Cænograptus gracilis, Didymo. superstes, Dicello. sextans, Dicrano. rectus, Dicello. divaricatus.* Middle and Lower Llandeilo beds of Meadowtown, Builth, etc., with *Ogygia Buchii, Didy. Murchisoni.*
	Ballantrae Terrane.	Ballantrae Series (restricted). With *Phyllo. typus, Tetra. bryonoides, T. quadribrachiatus, Didymo. bifidus, D. extensus,* etc.				Skiddaw Slates, with *Phyllo. typus, Tetra. bryonoides, Tetra. fruticosus, Tetra. quadribrachiatus, D. bifidus.*	Upper Arenig Rocks of Llanvirn, etc., with *Placoparia, D. bifidus, D. Nicholsoni,* etc. Middle Arenig beds of Shelve, St. Davids, etc., with *Tetra. bryonoides, Tetra. quadribrachiatus,* etc. Lower Arenig (and Upper Tremadoc), with *Bryograptus,* etc.

[To illustrate Prof. C. Lapworth's paper on the Ballantrae Rocks of South Scotland and their place in the Upland Sequence.]

(*To face page* 69.)

phenomenon must be referred to some peculiarity in the disturbances to which the rocks have been subjected.

To explain it, we must go to North Devon, a district, like North Wales and the Ardenne, deeply affected by great lateral pressures operating on the solid rocks. At various points of the coast east of Ilfracombe we find among the slates beds of limestone exhibiting a succession of swellings and constrictions analogous to those already described; and we see that this disposition is due to the welding together of the adjacent limbs of sigmoid folds under a powerful thrust. The stages of the process are clearly exhibited. After the formation of a series of S-shaped flexures in the ordinary manner (Fig. 1), the direction of the pressure relatively to the bed has



changed, and the folds have been pressed upon themselves in the fashion indicated in Figs. 2 and 3. A node corresponds to the attenuated middle limb of a fold, while a ventral segment represents the union of the complementary parts of two adjacent folds.

It appears probable that the process indicated is also that by which the varying thickness of the greenstone dykes and the quartzite beds has been brought about. It is also seen in various stages in thin bands of grit in the Ilfracombe district. It is not necessary, however, to suppose that the sharp sigmoid folds must be actually formed as a preliminary stage. A series of slight undulations, as in Fig. 4, affected by a shearing motion in the direction shown by the arrows, might equally give rise to the alternate nodes and swellings of Fig. 3.

V.—On the Occurrence of Soda-Felsites (Keratophyres) in Co. Wicklow, Ireland.

By Frederick H. Hatch, Ph.D., F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

In an Appendix to the Explanatory Memoir on Sheets 138 and 139 of the Map of the Geological Survey of Ireland (Dublin, 1888), I have given some notes on the petrographical characters of the igneous rocks of Co. Wicklow. One or two of the facts elicited by an examination of these rocks are sufficiently interesting to deserve a wider circulation.

Associated with various types of greenstone, which will form the subject of another communication, there occur in the Lower Palæozoic strata of this district (Bala) numerous beds of felsite. These are

frequently accompanied by felspathic tuffs: and there is no doubt that they are the product of contemporaneous extrusion during the deposition of the sedimentary rocks in which they occur.

Microscopical examination and chemical analysis show that these rocks consist, in part at least, of soda-felsites or keratophyres. The keratophyres (so named from their resemblance to hornstone[1]) were first described by Gümbel;[2] but it is to K. A. Lossen[3] that we are mainly indebted for the investigation of the characters of these peculiar rocks and the vindication of their claim to consideration as a definite rock-type. They are characterized by a remarkably high percentage of felspar, especially of soda-felspar, which in some cases appears to be soda-orthoclase or soda-microcline, in others, albite. In consequence, splinters of the rocks fuse more readily before the blow-pipe than the normal quartz-orthoclase-felsites.

Normally constituted felsite, that is to say, rocks composed of a cryptocrystalline aggregate of quartz and felspar (in great part orthoclase), with or without porphyritic quartz, also occur in the Wicklow District;[4] but there is little doubt that the two types graduate into one another.

Some specimens, collected from a rocky eminence a quarter of a mile west of Brittas Bridge, seven and a half miles west of Rathdrum (Sheet 130), will serve to illustrate the characters of the keratophyres of this district. The rock cropping out at this place is a compact felsite, having, when weathered, a curious mottled appearance, due to the presence of numerous greyish-brown spots of about a quarter of an inch diameter. These spots are crowded closely together, being only separated by a small quantity of a dark grey interstitial substance. Where still more exposed to the action of the weather, the rock is coated with an opaque white crust. When fresh it is of a dark bluish gray to black colour and splinters readily under the hammer.

Under the microscope it is seen to be composed almost entirely of felspar and quartz, the former being in excess. The few porphyritic crystals are invariably felspar, the quartz being confined entirely to the ground-mass. The texture of the latter is extremely variable. In general it is microcrystalline, consisting then of square and lath-shaped sections of felspar, between which are entangled irregular grains of quartz; in places, however, the texture sinks almost to cryptocrystalline, the individual granules becoming so small as to be scarcely distinguishable; but even then, by the use of a higher power, the microcrystalline structure can generally be made out, and there is no evidence of the presence of any "microfelsitic" (isotropic) matter.

Scattered sparingly through the sections are scales of chlorite,

[1] Gr. κέρας. a horn.

[2] Die palaolithischen Eruptivgesteine des Fichtelgebirges. Munich, 1874, p. 45.

[3] Zeitsch. deutsch. Geol. Ges. xxxiv. (1882), pp. 199 and 445; xxxv. (1883), p. 215; Jahrb. k. preuss. Geol. Landesanst. für 1884 (1885), p. 21.

[4] See Explan. Mem. on Sheets 138 and 139 of the Map of the Geol. Survey of Ireland, 1888, p. 50.

and isolated granules of sphene; occasionally also a few tiny specks of iron-ore.

The porphyritic structure is not well defined, there being but little difference in point of size between the "porphyritic" felspar and the crystals of that mineral in the more evenly crystalline portions of the ground-mass. It is only the occurrence of an isolated large crystal in a cryptocrystalline part that gives the porphyritic appearance. These large felspars form broad rectangular crystals, which are sometimes slightly rounded. In some cases they present a fine twin-lineation either on one (the albite) or two (albite and pericline) types. In other cases the crystals show no trace of twinning. Such crystals, however, are characterized by another and somewhat remarkable structure. They appear, namely, between crossed Nicols to be divided up into a number of rectangular patches by narrow partitions, which have an extinction-angle differing slightly from that of the main portion. In other cases the central portion extinguishes uniformly, while a marginal layer goes out at a slightly different angle. The latter case can sometimes be made out without the use of the Nicols; the rim of the felspar-section being clear, while the central portion is speckled over with minute opaque particles, giving it a somewhat cloudy appearance. Have these phenomena, more especially the first-mentioned, anything in common with the "felderweise mikroperthitische" structure mentioned by Lossen and Rosenbusch as characteristic for the felspar of the keratophyres? The smaller felspars of the ground-mass are mostly striated.

A chemical analysis of this rock gave me the following result:—

SiO_2	=	77·29
Al_2O_3 + Fe_2O_3 (a trace)	=	14·62
CaO (a trace)		—
MgO	=	·38
K_2O	=	·16
Na_2O	=	7·60
Loss on ignition	=	·57
		100·62
Sp. G.	=	2·64

From this analysis the mineral composition of the rock was calculated to be the following:—

Free quartz	=	32·49
Orthoclase	=	·95
Albite	=	64·33
Felspar		65·28
Other substances	=	2·23
		100·00

This analysis shows that the rock consists almost entirely of quartz and a soda-felspar (albite).

During two visits to Counties Wicklow and Waterford in June and November of last year I collected, among other rocks, a large series of felsites. It is exceedingly probable that a petrographical

examination of these specimens will demonstrate the wide distribution of soda-felsites in these districts. Felsites bearing a strong resemblance in age, association and mode of occurrence, to the Irish rocks occur in Wales. We may confidently expect to find keratophyres among them; indeed, Prof. Rosenbusch has already predicted their occurrence among the Welsh rocks.[1] They appear also to occur in Arran. An analysis of a felsite from this island by Mr. J. A. Phillips is almost identical as regards the alkalies with the one given above.[2]

It is interesting to correlate with the facts given above Prof. Haughton's researches on the Wicklow granites.[3] As far back as 1859 he showed that in many of these granites there is a dominant soda-felspar: and for these he introduced the name "soda-granite." An interesting relation has thus been established between the granites and felsites of Co. Wicklow. What bearing this has upon their mode of origin remains still to be seen.

VI.—An Analysis of the Kentish Rag.

By P. Gerald Sanford, F.I.C., F.C.S.,
Metallurgical Laboratory, Royal School of Mines, London.

In May last I visited the Preston Hill Quarry, near Maidstone, in the company of the "Geological Field Class," conducted by Professor Seeley, F.R.S., and took from it the specimen, the analysis of which is given below. In appearance the rock was a hard, grey, sandstone, containing fine quartz grains disseminated throughout its mass; its sp. gr. = 2·685; on the addition of an acid sulphuretted hydrogen was evolved, from the decomposition of calcium sulphide. The sample contained:—

Insoluble Residue	72·190 per cent	=	Silica	72·051 %
			$Fe_2O_3 + Al_2O_3$ =	0·137
Alumina	1·331 ,,	} = 2·068		72·188
Ferric Oxide	0·682 ,,			
Phosphoric acid, P_2O_5. ...	0·055 ,,			
Lime, CaO.	12·523 ,,			
Magnesia, MgO.	0·054 ,,			
Alkalies as K_2O.	0·122 ,,			
Carbonic acid	9·984 ,,			
Sulphuric acid, SO_3. ...	0·647 ,,	as insoluble Ca SO_4, no soluble sulphates.		
Calcium sulphide, CaS. ...	1·334 ,,			
Moisture, at 100°C.	0·995 ,,			
	99·917			

[1] Die Massigen Gesteine, Stuttgart, 1887, p. 418.

[2] This Magazine, Vol. IX. 1872, p. 540. I give the analysis for comparison:—

SiO_2 ... ... =	78·32
Al_2O_3 ... ... =	11·39
FeO ... ... =	1·67
CaO ... ... =	·13
MgO (a trace)	—
K_2O ... ... =	·20
Na_2O ... ... =	7·62
H_2O ... ... =	1·47
	100·80

[3] Trans. Roy. Irish Acad. vol. xxiv. (1859), p. 608.

VII.—On a Remarkable Sodalite Trachyte lately discovered in Naples, Italy.

By H. J. Johnston-Lavis, M.D., B.-ès-Sc., F.G.S., etc.

In the last two British Association Reports of the Vesuvian Committee, I drew attention to some very large masses of trachyte traversed, at the back of Naples, by the tunnel of the Cumana Railway. A full account of the stratigraphy of these will be deferred until some further excavations, now in progress, are completed. I propose at present merely to describe the earliest-discovered and most striking of these masses.

This trachyte is cut through on the E.N.E. side, at 1890 metres from the terminus end of the tunnel at Monte Santo, in a slightly oblique manner, which traverses it for 1980 metres on the southern side, and 2000 on the northern. Thus, it will be seen that the tunnel forms the chord of an arc, the circumference or boundary-line of the trachyte being directed southerly, or towards the present sea-coast. Both contacts are old escarpments, and at the W.S.W. end a talus is cut through of fragments of the trachyte and other materials, on which is superposed a series of pumice, ash, lapilli and vegetable soil-beds, representing many successive eruptions; the latter are also met with at the opposite escarpment, placed at a high angle of rest. We thus see that this mass was no doubt erupted as a subaerial lava-stream, probably cut back by the sea, or other denuding agents, to a vertical cliff, and subsequently covered by the different tuffs that constitute the hills above.

The rock is divided into rather large blocks by irregular cooling cracks, very similar to the Mont Olibano trachyte, which it most resembles in general characters. It is of light grey colour, with a somewhat bluish tint and earthy fracture, is harsh to the touch, adheres slightly to the tongue, and a drop of water falling on its surface is immediately absorbed. These latter characters are probably dependent upon actual spaces between the crystals and microliths, whilst the colour can be seen to be due to the admixture of glassy felspar with numerous minute dark particles. The sanidine crystals are mostly very thin, tabular in form, and show sections up to nearly two centimetres in length, in which Carlsbad twinning can be seen. A few rare but large individuals are compacter in shape, and prism-like, resembling those of the Drachenfels trachyte. Microscopically they are much fractured and fissured, very clear, with a few glass cavities, whilst in each fractured fragment much internal strain is evidenced by the ring of colours just within its outline. The sanidine is decidedly the most important constituent of the rock, and next to it we have the amphibole, which exists in two or three varieties. One is usually in larger crystals, attaining a maximum measurement of two or three millimetres or more, and commonly occurring as irregular crystalline grains, with sharp edges, as if fractured shortly before consolidation in consequence of the internal friction of the semi-solidified pasty mass. Some sections exhibited typical cleavage. The colour of this variety is yellowish

or greenish brown, and comparatively slightly pleochroic. The smaller crystals are also very irregular in shape, and range down in size to large microliths. Even when a comparatively well-formed rod is examined, no extinction can be obtained, the whole undergoing aggregate polarization, as if some molecular change had taken place, or as if each individual were constructed of an association of minute grains. By changes that have occurred in much larger crystals of extraneous enclosed masses, it would appear that these microliths and crystals really consist of a mixture of pyroxene and amphibole. Another fact is that the greatest darkening is obtained at two points in rotating through 90° between crossed Nicols corresponding with the extinction of these two mineral species. The other variety of amphibole is certainly more recent in formation, but seems to have undergone the same molecular change, for it is almost impossible to get any definite extinction. The crystals are well formed, and associated with cavities, and no doubt are the same as those that project as long rods from the sides of the vesicles of this rock. In colour, they are very dark bluish-green, faintly pleochroic, but their opacity prevents a just estimation of such.

The ground-mass consists principally of sanidine microliths of large size in fact, so large that in many cases Carlsbad twinning can be made out. Interspersed amongst these felspar microliths, and those of amphibole already mentioned, are numerous grains of magnetite, which apparently have crystallized mostly as octahedra, their form being partly obliterated by a rusty iron stain surrounding them. Rarely, highly refracting colourless grains occur of uncertain character, and within some felspars long four-sided orthorhombic? prisms with domes, of a fibrous-looking mineral, occur, which in some sections looks much like a triclinic felspar in structure. Some attempts were made to isolate one of these, but unsuccessfully, and, on account of their rarity, none other suitable examples could be met with.

Some parts of this mass of trachyte are vesicular, though the cavities are not very close together. There are also a certain number of fissures formed before the rock had quite consolidated. These vesicles and fissure-spaces are lined by a number of minerals which constitute the beauty and striking characteristic of this trachyte. Projecting from the walls of these spaces, long pseudo-hexagonal prisms, sometimes solid, at others tubular, occur; in the former case they are usually colourless, and as limpid as cut glass. In size they range up to and beyond one centimetre long, and from one to four millimetres broad. They may be traced by gradations to fine well-formed dodecahedra of sodalite, which are somewhat white or milky in colour. Associated with these sodalites are numerous rods of black amphibole, thin and long, usually about a millimetre broad and from a half to one centimetre and a half in length. Much rarer and irregular hollow-faced crystals of a black colour, with usually a rough submetallic lustre, which is commonly steel-black, but may be of dark bronze colour; most of these crystals are imperfect, and frequently arranged in chains. As far as I could make out, they

have much the form of a pyroxene with the faces 110, 100, 112 and 111 well developed. A few were sliced, and show under the microscope a yellowish-green mineral, changed on the surface and along the cracks to a dark almost opaque brown mass. Unfortunately no very characteristic cleavage or extinction angles could be obtained. A grain reduced to powder and fluxed with carbonate of soda gave a strong manganese reaction. These facts would seem to indicate that we have pyroxene crystals which are undergoing decomposition, either from the separation of an oxide or hydrated oxide of manganese, or the introduction of this from without. The former I take to be the correct explanation, since the brown stains only occur on these crystals and in their immediate neighbourhood, and also the amphibole rods are unaltered except where in contact with these pyroxene crystals.

In some of the vesicles are bunches of hair-like crystals of chocolate colour, which at first sight look like breislakite. Examined under the microscope they are seen as absolutely opaque rods, even to the smallest dimensions. Although easily visible as large sprays, the actual amount of material is very small, so that I was unable to obtain more than two or three milligrammes. Part of this was treated by the four acids, but proved very slightly soluble in HCl and HF.

The HCl solution gave a blue precipitate with K_3CyFe_6. Another portion was fluxed with alkaline carbonates and proved very refractory, lixiviated with subsequent addition of HCl evaporated to dryness, then, dilute HCl added and filtered. The filtrate gave strong iron reactions, whilst the filter was burnt, and the ashes treated with HF and H_2Go_4 evaporated and fluxed with PotBisulphate and a HCl solution made which gave faintly the reaction for titanium. With salt of phosphorus in reducing flame it gave a blood-red bead. From these reactions we may conclude that we have to deal with a compound containing principally titanium and iron, and the question remains open whether we have to deal with a fibrous hematite containing titanium (Scacchi has proved the fibrous mineral in the piperno to be an iron-oxide), or a fibrous rutile very rich in iron, or lastly perhaps a breislakite containing titanium.

Most of the cavities are completely lined by a carpet of minute sanidine crystals; but superposed on these, in a few, are small elongated hexagonal-looking prisms which rarely attain to more than half a millimetre in length and about a sixth in breadth.[1] Under the microscope they are larger in the centre, so as to appear fusiform, whilst the surfaces of the prism are striated longitudinally, so that in only a few cases can they be made out to be hexagonal. The prism is terminated sometimes by basal planes, but in others by a low pyramid.

Various attempts were made to measure the angle between the pyramid and prism, and most often with a resulting angle of 116°,

[1] Often poised delicately on the amphibole rods, or the fibres of the breislakite-like mineral.

but in some cases as much as 125° was obtained. Under high powers a large number of minute well-formed cubes about 0·02 millim. are observable attached all over the surface of these hexagonal crystals. What either of these minerals may be is a difficult matter to decide, but the striking resemblance of the hexagonal one and its analogous mode of occurrence would easily lead one to refer it to microsommite. Lastly, but rarely to be met with, are minute acicular orange yellow crystals that look at first sight like small titanites (semeline). In HCl, however, these dissolve with much effervescence, and the solution gives an abundant precipitate with ammonic oxalate, and, therefore, may be referred to scalenohedra of calcite.

The order of crystallization in the cavities seems to have been as follows :—

1, Sanidine ; 2, Amphibole ; 3, Pyroxene ; 4, Rutile ? ; 5, Sodalite ; 6, Microsommite ? ; 7, Calcite.

Strangely enough I have not been able to find a trace of mica, either in the matrix or in the vesicles. I am the more struck with this, since in some blocks of a very similar rock near Pianura, enclosed in the cavities with the amphibole are most beautiful large brown plates of biotite.

The minerals are no doubt sublimates, or more properly result from the reaction of different vapours under special conditions of temperature and pressure.

A bulk analysis of this rock was made with special precautions as to sampling and the avoidance of regions in which vesicles occurred. The results are given below :—

SiO_2	...	...	57·909
TiO_2	...	...	0·654
Al_2O_3	...	...	15·786
Fe_2O_3	...	...	6·807
FeO	...	...	0·010
MnO	...	...	0·230
CaO	...	...	2·986
MgO	...	...	1·656
Na_2O	...	...	6·013
K_2O	...	...	7·270
P_2O_5	...	...	0·007
Cl	...	...	0·606
H_2O	...	...	0·336
			100·270
Sp. Gr.	=		2·516

This analysis gives the composition of a trachyte somewhat similar to that of Scarrupata. The uncommon point is the high percentage of titanic acid.

What is remarkable is the very fresh appearance of this rock, whilst the minerals of the vesicles seem hardly to be altered, yet the bisilicates in the base are in a state of molecular instability, so that some doubt exists as to whether these changes are pre- or post-eruptive. The great interest of this trachyte will be its relationship to two other masses lately met with in its neighbourhood.

VIII.—Note on *Pleurotoma turbida*, Solander, and *P. colon*, Sow.

By the Marquis Antonio De Gregorio.

MR. EDWARDS in his beautiful work (Eoc. Moll. p. 311, pl. 32, fig. 2) described a species of *Pleurotoma* under the title of *Pl. turbida*, Sol. He regards *Pl. colon*, Sow., as a synonym, but not *Pl. colon*, Sow., in Deshayes. In this I think he was mistaken. The species described by Deshayes appears to me different from the *Pl. colon*, Sow., and identical with the species figured by Solander under the name of *Murex turbidus*. In the second edition of his work Deshayes says that he "noted this species for mischief," because it is not found at Soisson, but he retained the name of *colon*, Sow.

The species described and figured by Edwards appears to me different from *Pl. turbida*, and like *Pl. colon*. These last two species are thus distinguished.

Murex turbidus, Brander (Foss. Hant. pl. 2, fig. 31), has the costæ biseriated, the whorls excavated in the middle, the sinus of mouth situated in their depression. *Pl. colon*, Deshayes (non Sow.), is a synonym of the same species.

Pleurotoma colon, Sow. (Min. Conch. p. 106, pl. 146, figs. 7, 8), has the whorls swollen in the middle and nodulous, the sinus is placed on the periphery of the whorl. *Pl. turbida*, Edw. (non Sol.), is a synonym of it.

These two species, I believe, are not only distinct, but belong to different subgenera. *Pl. turbida*, Sol., belongs to the subgenus *Clavatula*. *Pl. colon*, Sow., to the subgenus *Strombina*.

Pl. turbida, Nyst. (Coq. et Polypières des Belgique, p. 513, pl. 40, fig. 8), differs from both, but it is more analogous to *Pl. turbida*, Sol., than to *Pl. colon*, Sow.; but it has the anterior canal more oblong and the ribs not interrupted in the middle.

To conclude, I believe that there are three distinct species:

Pleurotoma turbida, Brander (= *colon*, Deshayes).

Pleurotoma colon, Sowerby (= *turbida*, Edwards).

Pleurotoma turbida, Nyst.

For this last I propose the name of *Lethensis*, from the locality where it has been found.

Palermo, *November*, 1888.

NOTICES OF MEMOIRS.

I.—On some Fossils of the Limestones of South Devon.[1] By Rev. G. F. Whidborne, M.A., F.G.S.

FROM the three localities of Woulborough, Lummaton and Chudleigh about 334 species are known, of which 104 are common to the two former places, and five occur in all three; among these are *Orthis distorta*, Barr; *Pterinea Wormii*. F. A. Rö., *Pt. ala*, Barr., *A. rudis*, Ph., *A. plicatellus* (= *P. plicatus*, Ph., Pal. Foss.), *A. Cybele*, Barr., *A. consolans*, Barr., *P. lateralis*, Sow., *Hoplomytilus crassus*, Sandb., *Megalodon obliquus* (= *M. carinatus*, Ph. not Goldf.), *Pl.*

[1] Communicated to the British Association, Bath, Sept. 1888, Section C. Geology.

Vilmarensis, d'A. and de V., *Pl. pugnans* (= *Pl. minax*, Ph. Pal. Foss.), *H. interscapularis*, Ph. (including *H. depressus*, Aust.), *H. macrotatus*, Aust. (= *H. tuberculatus*, Ph. not Mill.), *H. ornatus*, Goldf., *Pl. fritillus*, Wiet. and Zieler; *H. Vicarii* (= *H. pentangularis*, Ph. not Mill.), *Pl. quintangulus* (= *Pl. pentangularis*, Aust. not Mill.), and *Rh. crenatus*, Goldf.?; *Receptaculites*, sp. and *Serpula*? *semiplicatus*, Sandb.; and also the following which are new, *Pterinea obovata*, a small deep species like *Pt. texturata*, Ph., but without concentric lamellæ; *Pt. placida*, flatter and more angulated than the last and with more distant ribs than *A. urbana*, Barr.; *Pt. dilatata*, which is larger and wider and with fewer and more distant ribs than the preceding, crossed by crowded growth lines; *Pt. crenatissima*, a longer shell with very anterior umbo, and covered with fine granulated lines crossing minute rays; *Pt. bellula*, a species like *Pt. fasciculata*, Goldf., but with few alternating ribs crossed by distant zigzag striæ; *Aviculopecten hirundella*, separated from *Pt. texturata* by its shorter hinge-line and finer reticulation (the right valve has transverse marks similar to those of *Pt. ala*, Barr.); *A. aviformis*, a flat recurved shell much produced and rounded behind with very small umbo and wings; *A. comma*, similar to the preceding, but much smaller and with reticulated surface; *A. gracilinus*, a flat elongate sub-equilateral form with minute umbo, notched anterior ear and close alternating ribs; *Mytilus Robertsii*, which is more ovoid and less produced in the postero-superior region than *M. dimidiatus*, Goldf.; *M. stultus*, a short squarish form with fine concentric striæ and a few stronger ones; *M. pinnoides*, which is shorter and has a more direct umbo than *M. uncinatus*, Eichw.; *Myalina elliptica*, a smooth convex ovoid shell differing from *Unio castor*, Eichw., in its more incurved umbo and less dilate wings; *Megalodon? columbinus*, separated from *M. carinatus*, Goldf., by its finer regular plaits, more terminal umbo and the contour of its elevated keel; *M.? prominens*, larger than the last, and with coarser wavy plaits, loftier and more projecting umbo and more oblique anterior margin; *Ctenodonta? lepida*, a small flat transverse shell, which is narrower and more convex anteriorly than *P. modiolaris*, F. A. Rö.; *Cardiomorpha? polita*, a flat oblique species unlike *A. damnoniensis*, Ph., in its smoothness and its shorter hinge-line; *Cypricardia neglecta*, with fewer stronger ribs and more definite wing than *M. scalaris*, Ph.; *C. guttata*, with fewer plaits and rounder indentations than *C. crenistria*, Sandb.; *C. ensiformis*, a much flatter and wider shell than *C. neglecta*, and with more and finer plaits; *Edmondia? dubia*, a large wide convex shell, with a recurved anterior umbo, deep area and close indistinct bifurcating growth lines; *Hexacrinus perarmatus*, with calix like *H. macrotatus*, Aust., but covered with sharp regular non-confluent tubercles; *H. microglypticus*, with a convex calix, very long basals and fine ornamentation; *Platycrinus aberrans*, with trilobed attachment, elongate calix, three squarish basals, four or five long radials intercalated with one large and one small subsidiary anal; *Haplocrinus decipiens*, a minute crinoid having a short calix with an elevated

conical summit with key-shaped grooves for the arms; *Tricælocrinus*? *Leei*, with shorter limbs and shallower excavations than *T. Woodmani*, Wachsm. and Springer; and *Serpula*? *devoniana*, a long straight smooth and cylindrical tube.

II.—Dr. Rüst, on the Occurrence of Radiolarians in the Cretaceous Strata.

Beiträge zur Kenntniss der fossilen Radiolarien aus Gesteinen der Kreide, von Dr. Rüst, in Hannover. Palæontographica, Bd. 34, 1888, pp. 181—214, Taf. xxii. bis xxix.

In his first memoir on the Radiolarians from the Jurassic rocks, which has been already noticed in the Geol. Mag.,[1] Dr. Rüst called attention to the apparent scarcity of these organisms in Cretaceous strata, but a subsequent examination of about two thousand microscopic sections of the rocks of this period has shown that they are very abundant in some of the lower beds, though very rare in the higher beds of the series. Thus, for example, a reddish hornstone of Neocomian age from Katzenberg in the Trauchgebirge was so filled with Radiolarians that it might properly be considered as a former "Radiolarian ooze." On the other hand, in the Upper Chalk only two species were found, and these were in limited numbers. They were very abundant in beds of the age of the Gault at Zilli, near Wasserleben in Saxony, at Oker and Goslar in Hanover, at Braussrote in the Basses Alpes, and at Escragnolles. In these Gault deposits the Radiolarians were mostly met with either in the body-chamber of Ammonites or in true Coprolites. In these latter they were invariably associated with spicules of siliceous sponges as well as fragments of other organisms, indicating, the author believes, that the animals which produced the coprolites largely fed on sponges. A peculiar feature of many of these coprolites is that they are almost entirely made up of small oval pellets, which are supposed to be casts or moulds of intestinal follicles of the Saurians or fishes through whose bodies they passed.

From the Cretaceous marls of Haldem in Westphalia Dr. Rüst only records the six species of Radiolarians, which were first discovered in these beds and described by Prof. v. Zittel, and from the flints of the Upper Chalk of this country he obtained but two species, *Dictyospyris chlamydea*, and *Dictyomitra Anglica*, both of them new forms. The author thinks that this paucity of forms in the Upper Chalk may indicate their comparative absence in the seas of this period, but it is not improbable that the same destructive action which has dissolved the siliceous skeletons of most of the Upper Chalk sponges, has been still more effectual in destroying the far more minute and delicate Radiolarian tests, most of which only range between one-twentieth and one-fourth of a millimètre in diameter.

From the Cretaceous rocks as a whole, 165 species included in 74 genera were obtained, of which 49 species occur in Jurassic rocks. In general characters the Cretaceous Radiolarians more nearly

[1] Dec. III. Vol. III. 1886, p. 79.

approach those from the Jurassic strata than the Tertiary and Recent forms. The new species are arranged according to the classification proposed by Hæckel in his Challenger work, and figures of them are given in the accompanying eight plates. Dr. Rüst also adds a tabular list showing the geological distribution both of the Jurassic and Cretaceous species.—G. J. H.

REVIEWS.

I.—Fossils of the British Islands, stratigraphically and zoologically arranged. Vol. I. Palæozoic, comprising the Cambrian, Silurian, Devonian, Carboniferous, and Permian Species. With Appendix to 1886. By Robert Etheridge, F.R.S. L. & E., F.G.S. 4to. pp. 468. (Oxford, Clarendon Press, 1888.)

THE ranks of our geological army, like that of most other special scientific bodies, are well-filled with workers of all kinds, nor are writers and compilers absent from its many-sided staff.

Text-books are now so numerous that it is often difficult to advise the tyro which to adopt,—nor are the writers of separate essays and memoirs by any means waning, to judge from the constant flow of these productions which find their way into the pages of the Geological Magazine, the Quarterly Journal, and other similar publications.

The writing of original articles, and describing individual specimens, form perhaps the lightest stratum of our geological architecture.

Monographs on special subjects have also their attractive aspect, but they may fairly be reckoned amongst the more solid portions of our palæontologic structure.

Text-books may be, and very often are, the necessary outcome of a long course of oral instruction, carefully and conscientiously given to students in training; or of an equally arduous pursuit of field-work; but some, doubtless, have originated mainly from a careful application of "scissors and paste," with connective tissue of more or less firm consistence—usually less.

But of those who mainly work for the benefit of others, none deserve our gratitude more than the compilers of Catalogues, especially of such a confessedly arduous work as that of a Catalogue of British Palæozoic Fossils, such as that now before us, prepared by Mr. Etheridge. Indeed, the sources of information lie so scattered, and so much diligence and discernment are needed in dealing with and assorting the varied matters to be gathered together, that one can hardly over-estimate the gravity of the task.

And when all is done—if it ever is done!—much promptitude seems needed to seize the right moment for publication and to get it out before the next flood-wave of new matter pushes the patient and indefatigable compiler back again and prevents him from ever getting his Catalogue issued, or at any rate before it must be

modified, owing to the progress of new palæontological discovery and new publications.

In 1830 Samuel Woodward, of Norwich, published the first attempted list of British fossils, a little book of fifty pages octavo, entitled "A Synoptical Table of British Organic Remains," wherein the number of recorded British fossils is given as 2008.

Prof. John Morris published the first edition of his Catalogue of British Fossils in 1845, and a second edition in 1854. It must not, however, be overlooked that in 1848–49, between the issue of the first and the second edition of Morris's Catalogue, the great work of Dr. H. G. Bronn, entitled "Index Palæontologicus," in three vols. 8vo. (Stuttgart), had appeared. This work really formed the most important and correct contribution to Palæontological nomenclature, giving us the most complete and accurate census of past life-forms ever attempted.

The author of the present work, Mr. Etheridge, is no novice at the task of tabulating British fossils, as may be abundantly proved from his very numerous published palæontological Appendices to the Memoirs of the Geological Survey (especially that to Vol. III. on North Wales), his great Memoir "On the Physical Structure of West Somerset and North Devon and on the Palæontological Value of the Devonian Fossils" (Quart. Journ. Geol. Soc. 1867, vol. xxiii. pp. 568–698), and his Anniversary Addresses as President of the Geological Society, 1881–82.

Mr. Etheridge also largely aided the late Dr. J. J. Bigsby, F.R.S., in the production of two very valuable Catalogues, one entitled "Thesaurus Siluricus" (4to. 1868), and the other "Thesaurus Devonico-Carboniferus" (4to. 1878).

In Prof. Morris's second edition are enumerated 8359 species of British fossils, from rocks of all ages; in the present volume, which gives a list of fossils recorded only from the British Palæozoic rocks known up to 1886, we find the number to be 6022 species, whilst those met with in the Neozoic formations (not included in the present Catalogue) number, according to Mr. Etheridge, no fewer than 13,000—giving a grand total for the British Islands of 19,022 species at the date when the present list closed in 1886.

Undoubtedly we are mainly indebted to Morris for the first really important *critical list* of British fossils, and this has been of the greatest use to workers in palæontology and also in stratigraphical geology, by directing them to those published sources of fuller information, such as Sowerby's Mineral Conchology, Mantell's and Dixon's works, the Transactions and Journal of the Geological Society, and later to the grand series of volumes of the Palæontographical Society, whose vast stores of information needed such a Catalogue raisonnée to make them available to the ordinary working student seeking to arrange and name his collection and to fix with certainty the horizon from which he had obtained his fossils.

Most of all do such works attain their highest usefulness when they can be appealed to as critical guides, and safeguards against the unnecessary multiplication of names in palæontology.

In that vast maze of modern scientific nomenclature to which the multitude of specialists have given origin, in which the student of palæontology finds himself too often entangled, it is no small matter to find some friendly clue offered ready to his hand, which if it will not in every case carry him safely out of the labyrinth, may at least give him a help in the right direction by showing him how to get at the reference he wants.

It is only right to state, with regard to the work before us, that ten years ago it was quite ready and ripe for publication; but owing to family illness and official duties having intervened, the work, which might have been issued in 1878, appeared only in 1888. As a consequence of this unfortunate delay, a very much larger Supplement has been found indispensable in order to bring the several long lists of fossils up to the closing date of 1886.

Turning a critical eye to the work itself, we are at once struck by the important difference in arrangement between Mr. Etheridge's Catalogue and that of its nearest predecessor, Morris's Catalogue of British Fossils (1856). In the latter work we had a small 8vo. page only, and the species from the oldest Palæozoic to the Recent were all arranged under their respective orders, families, and genera, the latter alphabetically, save in great groups, such as the Ammonites and the Brachiopods, which are simply subdivided into Palæozoic and Oolitic; or Oolitic and Cretaceous. In Mr. Etheridge's volume we have a large quarto page subdivided into ruled spaces and columns, with the genera and species alphabetically arranged under the great zoological groups, and further into Cambrian and Silurian, Devonian, Carboniferous and Permian, whilst their range is indicated through a limited number of geological subdivisions by asterisks placed in the column headed with the name of the formation, as Harlech, Menevian, Lingula Flags, Lower, Middle, or Upper Devonian, according to the several horizons included on the page.

Taking the genera and species, these are given with one or more references to the works published, but without localities, not as was the case in Morris's Catalogue.

Whenever a species has remained for some time under an earlier generic appellation than that by which it has since been recognized, it will be found duly recorded both under the old and disused genus and under the new and present recognized one, only the former reference is printed in *italics* and the latter in roman type, with a cross-reference to the newer name.

The earlier part of the Catalogue, up to p. 376, is provided with an admirable index.

The Appendix which follows, covering about ten years down to the end of 1886, is more concise in its references as compared with the earlier part of the work and it has also an index to it.

Without consulting this Appendix it might appear that the former part of the work was incomplete, which is not the case; but, taking a single group like the Sponges, a still newer revision of the genera has taken place subsequent to 1886, which will necessitate a further re-arrangement of these organisms whenever a new edition of this Catalogue shall appear.

The recent revision of the fossil Mammalia, the fossil Reptilia, and the Fishes—still in progress—will all materially affect the possibility of making a moderately complete catalogue of British fossils for some time longer, and then the new edition will have to be pushed forward in a briefer space of time through the press than has the present issue.

For owing to the large army of specialists which has arisen within the last 25 years, the task of the scientific compiler who undertakes to codify the long lists of species under each and every separate biological heading, becomes more and more difficult as the years roll on, and the Diogenes in Science who expects to find a perfect Nomenclator had better return to his tub and hang up his lantern.

Whilst, however, it cannot be overlooked that there are many literary defects as to words and references which have unfortunately remained uncorrected even in the list of errata and corrigenda at the end of the volume, we cannot ignore our great indebtedness to the author for the time and patience he has bestowed in bringing out the work under many trials and drawbacks only known to some few of his more intimate personal friends.

As might be expected of a work published by the Oxford University Press, the general aspect of these complex and difficult pages with their numerous columns—in some cases as many as twenty on a single page—is excellent and deserves great praise.

This labour of love which the author has now so happily completed, as regards Part I., has extended over fully thirty years of Mr. Etheridge's life, having been the work of his leisure hours and done quite apart from his official duties, indeed, having been carried on often into the hours which most men wisely set apart for "Nature's sweet restorer, balmy sleep."

We feel sure that every one will read with regret the author's announcement at the end of his Preface that, although the Mesozoic and Cainozoic portions forming Part II. of his Catalogue are completed in MS., his other occupations deter him from attempting the task of preparing the remainder for publication. It is to be earnestly hoped that with the assistance of friends this difficulty may yet be overcome.

Of one thing we feel sure, namely, that this first instalment of a much-needed and long-delayed work will be heartily welcomed by all, and will find its place as a work of reference on the shelf of every scientific library.

II.—Report of the Geological Survey of Ohio. Vol. VI. Economic Geology. Royal 8vo. pp. 831, with Maps and Figures. (Columbus, 1888.)

THIS volume is mainly devoted to a history of the origin and mode of occurrence of the natural gas and petroleum present in the rock-series of the State of Ohio. About four years since a deep well-boring in Hancock County, in the north-western part of the State, revealed the existence of large accumulations of carbu-

retted hydrogen gas and petroleum in limestone strata, about 1100 or 1200 feet beneath the surface. The rocks proved to be of Trenton age, *i.e.* Ordovician, about the horizon of our Llandeilo Flags. The existence of these products in workable quantities at this low horizon was an entirely new and unexpected fact to American geologists, and as the geological structure of Ohio is extremely simple, without breaks or important disturbances, and it was known that the Trenton formation would be found at depths varying from 1000 to 2000 feet beneath the surface, throughout the western areas of the State, wells were rapidly drilled in all directions. The great majority of these were unproductive, but in certain limited areas the yield of gas and petroleum has been on a marvellous scale. The facts brought to light by these borings were carefully collated by the Geological Survey of Ohio, and they are presented by Professor Edward Orton, the State Geologist, in a detailed and lucid manner in the present volume. Owing to the simple and undisturbed character of the geological series in Ohio, the questions affecting the origin and accumulation of natural gas and petroleum are more likely to be solved here than in areas where rock disturbances tend to make the problem more complicated.

In the north-western part of Ohio, beneath the mantle of boulder clay, the rocks outcropping at the surface belong for the most part to the Lower Helderberg series, the upper portion of the Silurian. These are mainly bituminous limestones, with an average thickness of about 300 feet. Beneath these in conformable succession, and with dips so small as to be scarcely appreciable, are the Niagara series of limestones and shales, and the Clinton series, together about 400 feet thick; then a thin deposit of Medina shales; beneath these the Hudson River or Cincinnati group of shales and limestones, with an average thickness of 600 feet, and the Utica shales 300 feet in thickness; under which the Trenton limestones are found. Both gas and petroleum are present in small and variable amounts in each of these different rock-series, but not sufficient to be of economical value. Even in the Trenton rocks, the accumulation of these products in workable quantities seems to depend on two conditions; first, a rise or elevation of the strata in the productive areas above the beds of those adjoining, and next, that the upper portion of the Trenton beds consists of a porous dolomite or magnesian limestone. This dolomite appears to have resulted from the alteration of true limestones; at all events, it occurs in patches surrounded by the normal limestones containing the usual fossils. The Trenton limestone itself has been penetrated for 500 or 600 feet, but it has been ascertained that the profitable accumulation of gas or oil was limited to the upper beds.

The facts point to the inevitable conclusion that the Trenton limestone is the source of the inflammable products; that resulting from artesian pressure they accumulate in the areas which are slightly elevated and where the rocks have become dolomitized and porous. The petroleum and gas can only be derived from the decomposition of the animal organisms, the skeletons of which now compose the

limestones. Judging from the fossils in this rock where it outcrops at the surface in other areas, the fauna is entirely invertebrate, and mainly consists of Crinoids, Trilobites, Brachiopods, Corals and Polyzoa. The volatile products of the decomposition are confined to the upper beds of the limestones by the presence of the massive overlying beds of the Utica shale. The animal origin of the petroleum in these limestones most probably accounts for the fact that the crude material contains a greater amount of sulphur, and is consequently more difficult to deodorize, so as to be suitable for burning, than the petroleum from the Pennsylvania wells, which in all probability is derived from the organic matter of bituminous shales, and is of vegetable origin. Prof. Orton is of opinion that in Ohio the petroleum has been produced at normal rock temperatures, and is not a product of destructive distillation of bituminous shales, and that the stock of petroleum in the rocks is already practically complete. This has been forcibly shown by the practical exhaustion of the supply in many areas which were at first productive, the place of the oil being taken by strongly saline water.

In certain localities in the north-eastern part of Ohio, where Carboniferous and Devonian rocks occur, an important supply of petroleum and gas has been obtained in a sandstone rock of sub-Carboniferous age, known as the Berea grit. The petroleum is believed in this case to be derived from thick beds of bituminous shale underlying the grit, and it is probably of plant origin. Prof. Orton likewise discusses the value of the Ohio (Devonian) shales in Ohio as a source of oil and gas. Many particulars are likewise given of the amounts produced, the mode of drilling the oil-wells, and the transportation and methods of using the natural gas.

G. J. H.

III.—Geological Survey of England and Wales.

1.—The Geology of the Cheviot Hills (English side). By C. T. Clough, M.A., F.G.S. 8vo. pp. 60. Price 1*s.* 6*d.*

THE country described in this Memoir belongs entirely to Northumberland; it is for the most part hilly, the highest point (Cheviot) being 2676 feet above sea-level. The oldest rocks, consisting of grey-green shales and greywackes, are grouped with the Wenlock Beds. They contain "apparently very few distinct fossil remains." These beds are overlaid unconformably by the Cheviot volcanic series—porphyrites, ashes, and ashy sandstones—grouped as Lower Old Red Sandstone. There is also a granitic core, probably of the same age. Higher still, there are representatives of Upper Old Red Sandstone, in certain conglomerates at Windy Gyle, etc.; these are not to be clearly separated from the conglomerates at the base of the Carboniferous system. The Lower Carboniferous beds are divided as follows:—

Fell Sandstones = Bernician (in part).
Cementstone Series
Lower Freestone (flaggy sandstones) } = Tuedian.
Basement Conglomerates.

The conglomerates probably occur on many different horizons, but when traced northwards into Scotland, they are associated with red and yellow sandstones containing undoubted Upper Old Red Sandstone fishes. Several basaltic dykes (in part, probably Tertiary) occur in the area. The remarks on igneous and eruptive rocks are based to some extent on researches made by Mr. Teall, but the author gives the result of much personal observation, and his notes on crushed granite are of especial interest.

A short chapter is devoted to Glacial Deposits, the author remarking that the higher summits of Cheviot, etc., seem never to have been over-ridden by foreign ice, but to have acted as independent centres of glaciation. There are also notes on recent accumulations (peat mosses, etc.), on the physical structure of the district, on some aspects of scenery in relation to geology, and on the economic resources of the area.

2.—The Geology of the Country around East Dereham. By J. H. Blake, F.G.S., etc. (Parts by H. B. Woodward, F.G.S., and F. J. Bennett, F.G.S.) 8vo. pp. 59. Price 1*s.* 6*d.*

IN this Memoir we have descriptions of the Chalk, Pebbly Series (Bure Valley Beds), Glacial Drift, River Gravel, and Alluvium. The district occupies the central portion of Norfolk, and includes (besides East Dereham) Litcham, Reepham, and North Elmham. Geologically speaking, the country is but little known, the previously published notices being confined to papers by the late S. V. Wood, jun., and Mr. Blake, and to references by the late C. B. Rose. A full list of fossils from the Chalk is now given, and detailed notes of the various pits and sections exposed. The Pebbly Series has yielded no fossils in the area now described, and its precise age is a subject on which opinions differ, Mr. Blake grouping it with the Glacial Drift, while Mr. H. B. Woodward places it in the Norwich Crag Series. A large part of the area is covered by the Chalky Boulder Clay, and this is overlaid in places by coarse "cannon-shot" gravel and sands. Notes on the economic resources, and records of a number of well-borings are given.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—December 19, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "*Trigonocrinus*, a New Genus of Crinoidea from the 'Weisser Jura' of Bavaria, with Description of New Species, *T. liratus*; Appendix I. Sudden Deviations from Normal Symmetry in Neocrinoidea; and Appendix II. *Marsupites testudinarius*, Schl., sp." By F. A. Bather, Esq., B.A., F.G.S.

This genus is proposed on the evidence of two calyces in the British Museum (Natural History), which were found among speci-

mens of *Eugeniacrinus* from Streitberg. The species of *Eugeniacrinus*, *Phyllocrinus*, and *Trigonocrinus* may be arranged in a series which is apparently one of evolution. The present genus is, therefore, to be placed with the Eugeniacrinidæ, although its characters are not those of the family as heretofore defined. This is seen from the following diagnosis:—

Trigonocrinus, gen. nov.—Calyx roughly triangular or trilobate in section. Basals 4, but one so atrophied as to be almost invisible; all fused into a basal ring. First radials 4; the two on either side of the smallest basal half the size of the others, thus maintaining the triangular symmetry; all closely united, with each suture-line in a groove. Processes of radials well developed, forming spines homologous with the petals of *Phyllocrinus*; excepting the adjacent processes of the smaller radials, which only form a minute ridge. Articular surface of radials curved gently inwards and upwards; muscular impressions indistinct or absent; no articular ridge; no canal-aperture. Arms unknown; ? represented by fleshy appendages. Calycal cavity contained in first radials; with small round ventral aperture, surrounded by a rim, which is the only relic of a muscular attachment. Stem unknown.

The two calyces belong to the same species, viz. *T. liratus*, sp. nov.—Calyx rather more elongate than in the known species of *Phyllocrinus*; basals ornamented with minute granules; radials ornamented with similar granules run into curved ridges, which, owing to their differing intensity, give an imbricated appearance; spines triangular in section, with the base of the triangle directed inwards, the apex outwards, the angles often rounded.

The differentiation of *Trigonocrinus* from the central Eugeniacrinid type has been effected on the one hand in accordance with the principles of "Degeneration," "Reversion," and "Use and Disuse"; while, on the other hand, it exemplifies certain methods of change in organic forms, which may be referred to the categories of (1) Sport, (2) Hypertrophy and Atrophy, (3) Fusion and Fission. Thus considered it is of unique interest among Crinoidea. An examination of the variations in symmetry presented by the Echinodermata suggests the conclusion that the Pentamerous type was originally evolved from another system, or at least that it was selected from among other variations, that it has survived, and that it has been kept true, as being the fittest.

Appendix I. Sudden deviations from normal symmetry in Neocrinoidea.

A collection of instances from previous authors, with a few additions, the whole illustrating the latter portion of the paper.

Appendix II. On *Marsupites testudinarius*, von Schlotheim, sp.

A synonymy of the genus *Marsupites*; it contains but one known species, and all other names must yield to this one.

2. "On *Archæocyathus*, Billings, and on other Genera allied thereto, or associated therewith, from the Cambrian Strata of North America, Spain, Sardinia, and Scotland." By Dr. G. J. Hinde, F.G.S.

A revision of the type specimens of the three species included by Mr. Billings in the genus *Archæocyathus* shows that each of the species represents a distinct genus. *Archæocyathus profundus*, having been selected by Mr. Billings in 1865 as the typical species, was retained as such, and the characters of the genus, as shown in this species, were defined; *Arch. atlanticus*, Bill., was made the type of a new genus, *Spirocyathus*; and the third species, *Arch. minganensis*, which proves to be a siliceous sponge, was included in a new genus, *Archæoscyphia*.

Including the genera allied to *Archæocyathus*, described by Meek and Bornemann, the following constitute the family ARCHÆOCYATHINÆ, proposed by this last-named author; *Archæocyathus*, Bill.; *Ethmophyllum*, Meek; *Coscinocyathus*, Born.; *Anthomorpha*, Born.; *Protophareta*, Born.; and *Spirocyathus*, g.n.

The genera of this family are characterized for the most part by turbinate or subcylindrical forms with stout walls enclosing an interior tubular or cup-shaped cavity. Their skeletons are of carbonate of lime in a minutely granular condition. The walls in the first four of the above-named genera consist of an outer and inner lamina connected by vertical and radial septa; dissepiments are generally present between the septa; save in the genus *Anthomorpha*, the outer lamina of the wall is regularly and minutely perforate, and the inner lamina and septa are likewise cribriform; *Ethmophyllum* is particularly distinguished by oblique canals connecting the interspaces of the wall with the central cavity, *Coscinocyathus* by transverse, perforate tabulæ, and *Anthomorpha* by the apparently imperforate character of the surface laminæ and septa. *Protophareta* and *Spirocyathus* are either non-septate, or very obscurely septate; their skeleton consists of anastomosing laminæ and fibres; in the latter genus the laminæ are remarkably thickened by successive secondary deposits of calcareous material.

The Archæocyathinæ are regarded as a special family of the *Zoantharia sclerodermata*, in some features allied to the group of perforate corals. The family is restricted, so far as is known at present, to the lowest fossiliferous zone of the Cambrian strata, that characterized by the genus *Olenella*, Hall, and it occurs at Anse-au-loup, Labrador; Troy, New York State; Nevada; in the Sierra Morena, Spain; and in the south-west of the Island of Sardinia.

The genus *Archæoscyphia*, based on *Archæocyathus minganensis*, Bill., is shown to be a lithistid sponge, and *Nipterella*, g.n., based on *Calathium* (?) *parādoxicum*, Bill., belongs likewise to the same group of sponges. The genera *Calathium*, Bill., and *Trichospongia*, Bill., are also undoubted siliceous sponges. These various sponges, which were either included in *Archæocyathus* by Mr. Billings, or regarded as allied thereto, have no relation whatever to the genus, or to any member of the family in which it is included. They come from a higher geological horizon, the Calciferous formation of the Canadian geologists, which is probably the summit of the Cambrian. They occur in the Mingan Islands and in Newfoundland. *Archæoscyphia* and *Calathium* are present in the Durness limestones.

3. "On the Jersey Brick Clay." By Dr. Andrew Dunlop, F.G.S.

This clay is of a dull yellow colour and somewhat sandy; in places it effervesces with acids; bedding and lamination have been noted. The lower part contains angular stones, usually with their longest diameter parallel to the surface of the underlying rock, and either derived from it or from some other rock not far distant. The bulk of the rocks consist of granite, diorite, rhyolite, quartz-felsite, etc., but there is an argillaceous shale, locally hardened, which is largely developed over considerable areas. The clay occurs in patches, covering all kinds of rocks, and is spread over the raised beaches; it seems more abundant on the higher grounds. A similar clay occurs in Normandy and in the other Channel Islands.

The author was disposed to regard this clay as probably a fluviatile deposit laid down towards the close of the Glacial Period, when the Channel Islands were at a lower level and united to the mainland. Subsequently he conceived that it might be the result of the decomposition of shale, felspathic porphyry, etc., some sections seeming to show this process as still going on; the clay, too, seems better developed over this class of rock; if so, it would require a moving force more energetic than ordinary rainwash.

II.—Jan. 9, 1889.—H. Woodward, LL.D., F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "On the Growth of Crystals in Igneous Rocks after their Consolidation." By Prof. J. W. Judd, F.R.S., F.G.S.

That the characteristic structures of the "granophyric" rock were not acquired by them during the act of consolidation, but have resulted from secondary changes taking place subsequently, was suggested in a former communication to the Society. Additional evidence was now brought forward concerning the nature of the processes by which these structures — variously known as the micropegmatitic, the centric or ocellar, the pseudospherulitic, the microgranitic, and the drusy or miarolitic—which are found in the peripheral zones and the apophyses of granitic intrusions, must have been produced.

That fragments of crystals in detrital rocks undergo enlargement and redevelopment has been shown by Sorby, Van Hise, Bonney, and many other authors. The fact has also been frequently recognized that curious outgrowths may often be detected in connection with the crystals of igneous rocks; such outgrowths have usually been regarded, however, as having been formed during the original consolidation of the rock.

In a "labradorite-andesite" (labradorite of French petrographers) belonging to the older or "felstone" series of ejections in the Tertiary volcano of Mull, large crystals of a plagioclase-felspar, near to labradorite in composition, are found to exhibit large and remarkable outgrowths of very irregular forms. The distinction between these outgrowths and the original crystals is rendered very obvious from the circumstance that the original crystals have been corroded by the enveloping magma and contain enclosures of the same, and

that they have been much cracked, and sometimes even partially kaolinized before growth recommenced in them. In some cases the crystals have been actually broken and recemented by newly deposited felspar-material.

While there is a general crystallographic continuity between the old felspar-crystals and the new outgrowths from them, the variations in the position of extinction in different portions of the enlarged crystal show that, as growth went on, the composition of successively formed zones gradually and progressively changed from near the anorthite limit to close upon the albite limit.

These facts prove that, under suitable conditions, felspar-crystals in solid rock-masses may grow at the expense of the unstable glass-magma by which they are surrounded. This conclusion is in complete harmony with some other recent researches—especially those of Dr. J. Lehmann on the mode of production of the perthite-structure in felspars. In conclusion, the circumstances which have given rise to the exceptionally clear illustration of the processes described in the rock under consideration were explained, and the bearings of the principles enunciated on the theory of metamorphism are indicated.

2. "The Tertiary Volcanoes of the Western Isles of Scotland." By Prof. J. W. Judd, F.R.S., F.G.S.

In his recently published memoir, "The History of Volcanic Action during the Tertiary Period in the British Isles," Dr. A. Geikie, while adopting many of the views propounded in a communication made to this Society in 1874, "On the Ancient Volcanoes of the Highlands," takes exception to certain of the conclusions which are maintained in that paper.

Among the ideas set forth in 1874, of which Dr. Geikie now announces his acceptance, and to which, indeed, he supplies valuable support and confirmation, from his own observations and those of various members of the Geological Survey, are the following:—

(1) The perfect transition between the plutonic rocks of the district (granites and gabbros) and the lavas ("felstones" and basalts), and the dependence of each variety of texture exhibited by them—from the holocrystalline to the vitreous—on the conditions under which solidification took place.

(2) The presence of great masses composed of volcanic agglomerates, breccias and tuffs, with numerous intrusive bosses, sheets, and dykes, at five well-marked eruptive centres, namely Mull, Ardnamurchan, Rum, Skye, and St. Kilda, and the subaerial character of the ejections at these five centres.

(3) The Tertiary age, not only of the lavas, but also of the gabbros and granites found associated with them at these different centres.

The conclusions to which exception is taken are as follows:—

(1) That the ejection of the "felstone" lavas and the intrusion of the granites preceded the appearance of the basalts and gabbros.

(2) That the five centres of eruption mark the sites of as many great volcanic cones, now ruined and dissected by denudation.

The view that the acid rocks were, as a whole, older than the basic ones, was originally put forward by Prof. J. D. Forbes and Dr. F. Zirkel, and is supported by the memoir of 1874. Dr. Geikie admits that, around several of the centres indicated, basalts may frequently be seen resting on more acid rocks; but the latter he regards as being, in every case, of an intrusive character; he also allows that the tuffs intercalated with the basalts often contain fragments of felsite, but he does not accept this as a proof that the felsites must have been erupted before the basalts. Much of the divergence of opinion that has arisen appears, however, to be due to the circumstance that Dr. Geikie classes as basalt many of the dark-coloured lavas (augite-andesites, etc.), which were, in the original paper, grouped under the name of "felstones." In these "felstones" the granites and gabbros alike were shown to be intrusive; and it was also admitted that there were many intrusions of acid rocks of later date than both the "felstones" and the basaltic lavas.

With respect to the existence of great volcanoes in the district, Dr. Geikie, while confirming most of the statements which were made in 1874 as to the several centres of eruption, prefers to refer the origin of the great plateaux of basaltic lava to "fissure-eruptions." He maintains that the numerous basic dykes of the district mark the actual cracks through which the lavas in question rose up and welled out at the surface.

In opposition to this view, it was pointed out that the numbers and dimensions of the Tertiary dykes are not such as would warrant us in inferring that they formed the conduits through which the enormous masses of lava forming the plateaux were erupted; and the absence of all proofs of contact-metamorphism at their sides, and of evidence that the majority of them ever reached the surface at all, was commented upon. In 1874 it was pointed out that some of these dykes appeared to mark the radial fissures on which sporadic cones ("puys") were thrown up, after the great central volcanoes became extinct; and this view is supported by the circumstance of the close analogies between the materials erupted at this later period, and the rocks which constitute some of the undoubtedly Post-Mesozoic dykes.

Dr. Geikie supports his view that the plateau-basalts of the Western Isles of Scotland and of Antrim were formed by "fissure-eruptions," by facts which he noticed in the Snake-River country, in the year 1879, while he was making an excursion to the Yellow-stone Park, and also by observations made by Captain Dutton in the Grand Cañon country, in Utah, and in New Mexico.

With respect to Dr. Geikie's own observations, it was pointed out that geologists who have had more time and opportunity for the detailed study of the district in question, like Captain Reynolds, Dr. Hayden, and Mr. Clarence King, all agree that there is abundant evidence of ordinary volcanic action having occurred in the Snake-River country; and the last-mentioned author distinctly points out the great paucity of dykes, and the absence of any evidence of the existence of fissures such as those from which "fissure-eruptions" are supposed to have taken place.

Captain Dutton, although originally inclined to refer the lava-fields of the Western Territories of the United States to "fissure-eruptions," has, since his visit to Mauna Loa, and his study of the floods of basalt that have flowed from that volcano, very candidly confessed that, in view of these later observations, he is no longer prepared to maintain his original position.

If the effusive action taking place at many volcanoes be rightly understood and appreciated—and the recent very interesting researches of Prof. J. D. Dana in the Sandwich Islands have thrown much new and important light on this subject—the theory of "fissure-eruption" will be found to be as unnecessary as it is vague. At some volcanic centres there is a preponderance of explosive action; at others the main result consists in the extrusion of lava-currents; while in most cases we find a combination of both kinds of action. The Tertiary volcanoes of Scotland, like the existing volcanoes of Iceland, are interesting as exhibiting evidence of both the effusive and the explosive action on the very grandest scale.

CORRESPONDENCE.

UNIFORMITY IN SCIENTIFIC BIBLIOGRAPHY.

Sir,—Mr. Davison's suggestion in the Geological Magazine for January, that the British Association should appoint a committee for securing a uniform and intelligible system of quotation of scientific serials is a very good one. Experience, however, shows us that many compilers, from carelessness or conceit, do not trouble to use those intelligible abbreviations which are employed in Bibliographic lists already published, and therefore, *not seeing the necessity* of making their references clear to those outside their subject, they possibly may not take any notice of another list, even though it receive the authority of the British Association.

Mr. Davison proposes a rearrangement of titles of serials, which is decidedly open to very serious objections. The experience of those who have had to deal with large libraries and bibliographic work finds that it is misleading and disadvantageous to alter the plan of the title or use any other than that on the title-page of the volume. If once the rearrangement of titles be permitted, individual idiosyncrasies would come into play, and we should have the same serial in two, three, or more disguises.

Nor can we take the place of meeting as a guide for library reference; but the systematist must take the place of *publication*, this being the method at all large libraries and in all the best catalogues.

The best plan in making references is to give the title of a serial in the perfect sequence in which it is printed on the title-page of the identical volume referred to, abbreviating the necessary words only, so as to be perfectly intelligible to one unacquainted with the serial, and give the name of the place of meeting in full (or if, as is often the case, no place is mentioned, it is as well to insert it in parenthesis), add the place of publication at the end of the quotation, and

the reference will be complete. This method, followed by all who have dealt with the subject in an extensive and practical way, is found to be the only one that will work satisfactorily.

C. Davies Sherborn.

UNIFORMITY IN SCIENTIFIC BIBLIOGRAPHY.

Sir,—Concerning the manner of quoting works of reference, I also have to make complaint, namely, that authors sometimes quote, as if it were a complete work, a paper which may be part of some larger publication.

Authors, however, are not always to blame in this matter, because it arises from the cause upon which I have another complaint, namely, that some of the Societies who issue Proceedings, etc., often fail to state on the "Authors' copies" anything at all concerning the fact that the papers are extracts from their publications.

Some of our County Field Clubs are adepts at withholding information. Sometimes they append no date at all to their publications; while their authors' copies suffer, in addition to the omission mentioned, from absence of date, absence of number of volume, and changed paging. I notice that even the Geological Society omits to give the volume number upon its "authors' copies."

I would suggest that the Council of the Geological Society first rectify this matter, and then issue a strongly-worded circular to every Secretary or Editor of every scientific society in the kingdom drawing attention to these omissions, and stating what is required.

Since it is the habit of some booksellers and private individuals to break up odd volumes of Proceedings into their different papers, I would suggest that it is also recommended that these data be printed at the heading of every paper in every volume of Proceedings; at present such information is lost if one happens to buy the parts of volumes so treated.

Date of papers.—I cannot agree with Mr. Davison (Geol. Mag. Dec. III. Vol. VI. No. I. p. 48) that the date of reading be taken as the date of a paper. A new species must date from the time when it is figured, and this cannot happen until the publication of the volume. If authors' copies be printed in advance, they should be so dated, both themselves and in the volume.

S. S. Buckman.

Stonehouse, *Jan.* 7, 1889.

PROFESSOR BLAKE'S "MONIAN SYSTEM."

Sir,—Professor Blake's reply to my "Notes" on his "Monian System" requires a few brief comments.

Prof. Blake now admits the presence of true schists as derived fragments in the Upper Archæan of Anglesey; but he attempts to neutralize their effect by alleging examples where such fragments occur in the upper part of the formation from which they are derived. He says, "The conglomerate of Bull Bay is made of the underlying quartz rock." But he has to prove that the quartz rock was not of contemporaneous origin, if the cases are to be parallel.

The schist in the Llanfechell Grit is not of volcanic origin *tanquam* schist; it must have originated as rock, and been metamorphosed into a schist, before the grit was deposited. The metamorphism must have taken place at some depth, and there must have been a period of denudation previous to the exposure of the schist at the surface. His examples of the conglomerates of Llangefni and some of the Bangor beds are not to the point; since the fragments derived from the associated beds are volcanic, and contemporaneous denudation in volcanic rocks is common enough. That the "conglomerate of Moel Tryfaen is largely composed of the immediately preceding Cambrian slates" I dispute. I have seen this conglomerate on Llyn Padarn, and I followed it all along the crest of Mynydd y Cilgwyn, but not a bit of Cambrian slate did I find in it. Dr. Hicks studied it in the intermediate ground of Moel Tryfaen without finding slate. I therefore venture to reject all Prof. Blake's supposed parallel cases, and I call upon him to prove that a true crystalline schist could have been included as a derived fragment in a (roughly) contemporaneous sedimentary formation.

As to Llyn Trefwll, I am quite aware that a large part of the ridge close to my sections consists of basic igneous rocks; but as they had no bearing upon my work, I have not referred to them. The rock *in situ*, which Prof. Blake now admits is a true slate, on the authority of Prof. Bonney, contains rounded pebbles of the adjacent granite; and Prof. Blake has no right to say either that I mistook diabase for slate, or that I sent to Prof. Bonney certain derived fragments in mistake for rock *in situ*.

I am sorry the two examples of a supposed passage between the "lower and upper groups," which I selected because they happened to turn up first, prove to be bad ones. Perhaps Prof. Blake would consider his succession in the northern area more satisfactory. If so, I do not think he will mend matters. He makes the Llanfechell Grit to overlie the schists of Mynydd Mechell; but there is more reason to believe that they are one and the same set of beds in different stages of alteration.

Prof. Blake has disappointed me. I asked for particulars of the fauna by whose aid he correlated the Longmyndian with the Bray Head Series, and he refers me to *Arenicolites didyma!* I supposed I must have overlooked some important palæontological discovery; but no, our familiar little friend turns up in immortal bloom! I respect *Arenicolites* for its antiquity, but as a time indicator it is worthless.

The "Malvernian" rocks, which I said were included by Prof. Blake in his "Middle Monian," are called by him "the granites and altered rocks of Primrose Hill." I do not think any one who knows the region disputes that these masses are approximately of Malvernian age.

Prof. Blake dwells upon the consequences of my acceptance of the igneous origin of the hornblende schists. I stated those consequences unreservedly in my "Notes," and I do not feel a bit ashamed that I worked on the accepted principles of our science, and was not able

to penetrate the "dim and distant future." My descriptions of the older Archæan rocks and their distribution are not materially affected by the theory of mechanical metamorphism; but we must of course cease to construct time-series out of them. Alas! how many a stately time-edifice goes down before the blows of those gods of the hammer, Lehmann and Lapworth! CH. CALLAWAY.

THE SERPENTINE OF THE LIZARD.

SIR,—Would you kindly allow me to reply to the letter of Prof. Bonney in your January issue on the above subject regarding my alleged "two slight errors."

1. I think the Professor's mind has very naturally (perhaps without reference to the map) reverted to the south end of the Pentreath Beach, where the hornblende schist occurs in conjunction with the serpentine, which he has so ably and minutely described; but the dyke in question is at the north, or Kynance end, near a large exposure of banded gneissic rocks forming the foreshore of Holestrow, similar to what occurs in many other localities described by the Professor as "granulitic," as at Caerleon and Kennack, at the west end of which latter Cove the dykes cutting the serpentine are seen to coalesce with the "granulitic" rocks forming the foreshore.

2. For my own part I know of no "granulitic group" in the whole area with igneous rocks involved or included in it, but a group of rocks to which the term "granulitic" might be applied, which every evidence seems to point at as having a common igneous origin, although differing widely from each other; neither do I know any separation between these and the hornblende schists save in the extremes of their compositions, both of which are frequently mingled together in the same dykes.

I quite agree and deeply feel with Prof. Bonney the very great difficulties connected with some of these Lizard rocks, such as the explanation of the banded gneissic series which has been so philosophically dealt with by Mr. Teall; and it was for this very reason that I ventured my short communication on the dyke and its lessons, in the hope that it might throw some little additional light on these gneissic and other rocks, which I have always regarded as presenting very much that is problematic. ALEX. SOMERVAIL.

59, FLEET STREET, TORQUAY, *Jan.* 9th, 1889.

MISCELLANEOUS.

ADDENDA.—In the section illustrating Prof. Hughes' paper, GEOL. MAG. Jan. 1889, p. 9, the asterisk indicating the third fossil locality mentioned in the text has been omitted. The spot referred to is immediately under the Bronllwyd Grit, vertically below the Y of that word on the diagram.